POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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MAGIC

Jane Froman, Radio and Follies Star in Action. (Photo National Broadcasting Co.)

IN A BEAUTIFULLY designed and tastefully appointed room in a magnificent ultra-modern building in the heart of New York City, a young woman is singing, softly, to the accompaniment of a grand piano. Except for one other person she and her accompanist are alone in the room. As she sings, she stands very erect, yet gracefully, before a curiously fashioned metal standard carrying at its upper end a delicately constructed contrivance which seems to fascinate her, for her gaze never wanders from its direction. Except for her clear sweet voice and the soft accompaniment of the piano, the room is impressively silent. The soft radiance of shaded lamps enhances the effect. It is mid-summer.

Eight thousand miles to the south, in a crude, snow covered hut on the edge of the great ice barrier which surrounds a lifeless Antarctic continent, a small group of bearded men sit, fascinated, before another curious contrivance—a sort of parchment disc firmly mounted on a convenient base on which it stands. This room, though vastly different from the first one in its appearance and its appointments, still has something in common with it, for here, too, even above the roar of the Antarctic gale outside, for it is mid-winter, can be heard the voice of a young woman singing, clear and lovely—the same girl's voice!

Wonderful? Marvelous?

Marvelous indeed—almost beyond the scope of human belief! For by what strange power, unseen, unheard, unfelt, is this girl's voice in all its complexity, with all its infinite gradation of tone and expression hurled across the continents and oceans of the world into the bleak Antarctic? In what mysterious way is it possible for this exquisite, this delicate, fragile voice to make itself heard throughout the length and breadth of the world? For while these men, in the shadow of the South Pole, are listening, so, at the same time, millions of others throughout the world are listening to the same voice. What strange magic is this—how is it accomplished?

In an absolute sense, nobody knows exactly how this astonishing feat is accomplished though its accomplishment is so ordinary an occurrence that it is accepted with the utmost unconcern. All we know is, that it is brought about by means of electromagnetic radiation through the agency of that marvelous product of human intellect and mechanical ingenuity, the vacuum tube.

The vacuum tube! Surely no Aladdin's lamp that intrigued the fancies of our youth ever exceeded, if indeed equaled, in wonder the power of this modern Aladdin's lamp, nor was any genie of our story books ever more slave to a lamp than is the modern genie, Electricity, slave to the laws of the vacuum tube.

Just what is this device? What is the secret of its amazing power? Is it something that we, as power plant operators and designers should be familiar with? Can it be of use to us in our work?

These questions which probably have occurred to many engineers at various times obviously cannot be answered here but in a series of articles, the first of which appears on page 110 of this issue, they will be considered at length and, we hope, answered.

NOR WAS ANY GENIE OF OUR STORY BOOKS MORE SLAVE TO A LAMP THAN IS THE MODERN GENIE, ELECTRICITY, SLAVE TO THE LAWS OF THE VACUUM TUBE

WITH THE EDITORS

By Its Absence Ye Shall Know It

IN AN ARTICLE ON the electric power system of New York City which appeared in these pages several years ago, we discussed the "matter-of-fact-ness" with which the people of New York regard the highly artificial atmosphere in which they live, their almost absolute dependence upon electric power for example. Very few of the six million people who live there ever give more than a passing thought to the power which governs the greater part of their activities. Electricity? Certainly we need it; the power company makes it—we press the button. Why worry?

But as we pointed out, let that electricity supply be interrupted for ever so short an interval of time; let the lamps be darkened for the most fleeting instant and what a howl of anguish ascends to the heavens! And if it fails for any length of time? Panic, paralysis, chaos, millions marooned in skyscrapers or trapped in subways, all dark. A thousand telephone calls, ten thousand protests in the course of a minute. Then, and then only, by the absence of it does the population become electricity conscious and then also all the explanations and excuses of the power company are of no avail.

How true this picture is, was sadly discovered recently upon the occasion of a serious short circuit at Hell Gate Station—a short circuit which plunged the upper part of Manhattan and the Bronx into darkness and confusion. Occurring at 4:16 P. M. it could scarcely have happened at a more criticial time and it resulted in widespread confusion. Hundreds of subway cars were halted, thousands of passengers trapped underground in trains, traffic lights failed resulting in traffic jams, seven telephone exchanges went dead, the police teletype system went out. More serious than train stoppage even, in the subways water seepage presented problems and in some cases emergency pumping equipment was impressed into service to keep the water level below the third rail. On the street the spirit of opportunism asserted itself eloquently in the sale of candles at 50 cents each.

Amusing was the concern of public officials and the charges made concerning the accident. The smoke had scarcely cleared away before a dozen investigations were under way. Mayor La Guardia, it is said, immediately "took charge" though just what the honorable mayor took charge of is not definitely known. There were rumors of sabotage and charges of undermanning and, though it has not yet come to our attention, Moscow was probably blamed. There were all sorts of conjectures as to the cause of the accident and, strangely enough, the newspaper reporters' old standby, "crossed wires" never appeared once in the subsequent news reports. "The cause may never be known," said one report. "Electrical engineers throughout the world will probably be studying what happened at Hell Gate for months," said another.

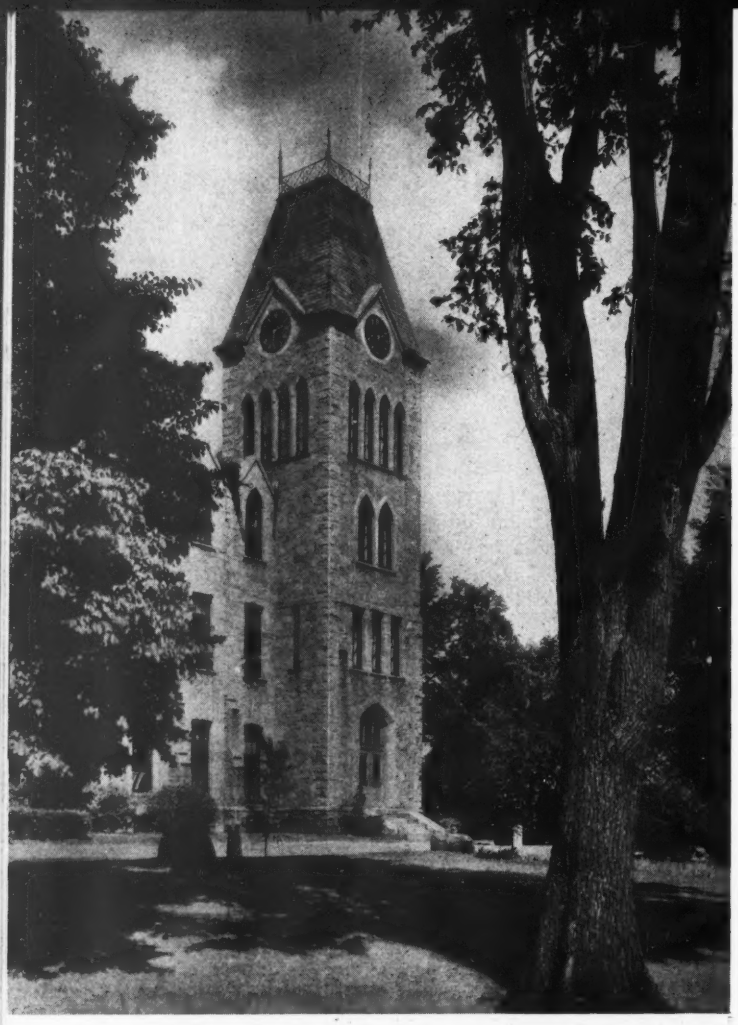
Apparently it never occurs to these various public minded gentlemen who become so concerned when the power fails, that when hundreds of thousands—even millions of kilowatts of energy are concentrated in such a city as New York, these things are liable to happen. The fact that they do not happen more often is high tribute to the character and quality of service rendered by the electrical engineer. After all this was only the first serious power failure in the history of the service and this lasted only an hour or two and affected only part of the city. When the politicians and public spirited gentlemen who become so concerned upon an occasion of this kind have done half as good a job as the engineers, then perhaps their concern can be justified. In the meantime they will probably remain unaware of power except when it fails.

Responsibility for Safety of Equipment

FOR MANY YEARS insurance companies have assumed risks due to failures of boilers, flywheels, steam engines and more recently Diesel engines. To this practice must be given much credit for the improved reliability of power plant equipment. In design, the equipment must meet the underwriter's specifications or no insurance will be issued. Regular inspection by an expert protects the insurance company against loss due to deterioration and opens up a channel through which the men in charge of operation may be given instruction in the care and maintenance of insured equipment. Most important, however, is the fact that dangerous or near dangerous conditions are brought forcibly to the attention of the owners of the plants.

Today many power plants are in a run-down condition with equipment that is not only obsolete but through years of use and idleness has worn out and deteriorated to such an extent that keeping it in service is a positive danger to the plant as well as an unwarranted expense for inefficiency, repairs and lost production time. The insurance inspector is in a position to point out these conditions to the assured as it is upon his judgment that the insurance company assumes financial responsibiliy for the safety of the plant. Refusal to renew insurance will almost invariably call for an explanation and perhaps a detailed study of plant conditions directed by an impartial engineer.

Company organization should be, and in many cases is, such that the power engineer is held responsible for the operation of the power plant. Given this responsibility, his plant must pay its own way and the expenditures made must be under his control. If some other official is responsible for major expenditures, inefficient results may surely be expected and it is in such cases that the company may expect occasional refusal of insurance on its equipment as a result of the inspector's report. Thus a refusal to renew insurance is not so much a criticism of the operating staff as it is of the management that permits or compels the operation of equipment that is not safe.



Power Plant Worcester

Thirty-year Old Vertical Fire-tube Boilers Give Way to Modern Water-Tube Unit in Rehabilitation Program. Space Limitations Present Unusual Problems in Providing Plant with Coal Handling Equipment and Test Facilities

By GUSTAF A. GAFFERT
Superintendent of Light, Heat and Power, Worcester Polytechnic Institute

PRIMARILY, the power plant of an educational institution exists for furnishing heat and steam for experimental work, and it is usually advantageous to generate the electricity necessary for light and power from the same steam, the prime mover acting as a reducing valve. Owing to increasing load demands and obsolescence, it is occasionally necessary to replace both the steam generating units and prime mover equipment. The Worcester Polytechnic Institute, Worcester, Mass., found itself in this situtaion in 1935 and started its rehabilitation program.

The power plant was constructed in the year 1894 with a portion of a grant from the Commonwealth of Massachusetts. At that time turbines were still in the experimental stage, and the original equipment finally selected consisted of a compound steam engine set and vertical fire-tube boilers of the Manning type. All three engines were belted to a common shaft which supplied power to the Washburn Shops, a commercial shop which was also used for student instruction in machine shop practice. Two vertical steam engines, a Ball and a Westinghouse engine were added later, and the compound engine set retained for student instruction. As the electrical load increased, it became necesary to have a larger capacity main generating unit, and in 1925 a 250-kv-a. non-condensing steam turbine designed to operate with dry steam at 160 lb. per sq. in. gage at the throttle was installed. During the past summer this unit has had a complete overhauling and inspection insuring continuous operation for years to come.

Repair Costs Became Prohibitive

It became evident during the winter of 1934 that the boiler plant needed rehabilitation since tube replacement had become a considerable item. Also the condition of the shells on two boilers was such that it would be necessary to lower the operating pressure from 175 lb. per sq. in. gage the following year. Three boilers of the fire-tube type, each containing 2600 sq. ft. of heating surface and designed for an operating pressure of 175 lb. per sq. in. gage comprised the steam generating plant. As installed, boilers Nos. 3 and 4 were 30 yr. old, and boiler No. 2, which has considerable welded construction, is only 7 yr. old. Each was fired by a Jones underfeed, single retort stoker, and forced draft was supplied by a two-speed fan. A stack 90 ft. in height above the grate carried away the products of combustion. Instruments for observation of combustion conditions were located as seemed best either on one gage board or in front of each boiler.

Replacement of boilers Nos. 3 and 4 with any other type of boiler except one of a vertical type presented difficulties since the floor area was limited. The normal method of firing, that is, from the division wall between the boiler room and turbine room could not be followed, and after considering several possibilities the boiler location and orientation shown was adopted. As to method of firing, oil appeared to be too costly, and pulverized fuel, while giving higher efficiencies, would probably spread fly ash throughout the campus. Also two Jones stokers were made available through the removal of boilers Nos. 3 and 4, and it was decided

Rehabilitation *at* Polytechnic Institute

to arrange these in double retort setting. To economize on room, it was found advantageous to fire the boiler in a reversed manner, that is, through the normal bridge wall where a head room of 9 ft. was available.

A check of the feedwater flow to the boiler for the past few years showed that a maximum load of 15,000 lb. per hr. could be expected. With due allowance for campus expansion, the maximum steaming capacity of this boiler was set at 18,000 lb. per hr. A plan of development as shown in Fig. 1 was decided upon, with the present installation of one boiler and future replacement of the last fire-tube boiler with another similar water-tube boiler. A Riley boiler of the 4-drum type having 2540 sq. ft. of heating surface was selected to generate slightly superheated steam at 175 lb. per sq. in. gage. A view of the boiler during erection is shown in Fig. 2. This cut shows clearly the generating tubes and method of support of the drums. The furnace is 7 ft., 6 in. wide by 8 ft. deep and is lined with first quality Reliance firebrick backed up by red brick throughout the first pass. Second quality firebrick is used in the second and third pass. On the walls adjacent to the aisle side and firing side, second quality firebrick is used on the exterior walls with thin joints and makes an attractive setting.

An analysis was made of the quality of feedwater available from the city mains to determine whether feedwater treatment would be necessary. Inasmuch as the water was quite soft, it was decided that none should be installed. To prevent possible oxidation of the boiler drums, however, they were sandblasted prior to erection. Since electronite tubes, which had already been pickled, were used in the boiler, sandblasting of these was unnecessary. After erection and hydrostatic test, the whole boiler, including tubes, was given two coats of Apexior, preceded by a thorough derusting of the metal surfaces using a power driven air brush.

Limited Space Available

With access limited to one side, all of the furnace doors, soot blower heads, man hole access doors, and the water column are located on the side adjacent to the grating as shown in Fig. 3. Soot blower steam is taken from the dry or fourth drum and distributed to the various soot blower heads which are of the latest Vulcan soot blower design. Four soot blower elements in all are used, two of the elements in the first pass being made of Vulcrom and the remaining elements being plain. The exceptionally limited access is noticeable, in Fig. 2, on the rear of the boiler and on the side opposite that from which the photograph was taken. All chains are brought down to the level of the operator's head on the main operating floor to facilitate control. These include outlet damper chains, soot blower and supply valve steam control chains, and water column chains.

Handling of coal from storage to stoker hopper was a difficult problem. As laid out, a large steam exhaust main sets the maximum possible elevation of the coal handling track above the main operating floor. A screw conveyor was too costly and would require aisle room, and overhead coal storage was not feasible. An I-beam was, therefore, electrically welded to a structural steelwork on the boiler and brought out to a point 2 ft. above the existing coal trolley track, as indicated in Fig. 3. A low headroom type spur geared trolley hoist is mounted permanently on this I-beam, and serves to hoist the coal bucket from the rail in place and transport the bucket to the stoker hopper. The hopper was designed with a steep slope on the sides to accommodate bucket clearance.

Combustion Control

The twin retort stokers are steam driven from a steam distribution motor actuated device located centrally for the present boiler and future boiler, as indicated in Fig. 4. All steam distribution piping is run under the main floor in a trench covered with floor plates. Combustion air is normally supplied by a two-speed motor driven centrifugal fan, located as shown in Fig. 1. All sharp corners in the duct work have guide vanes to reduce pressure drop. The outlet of the

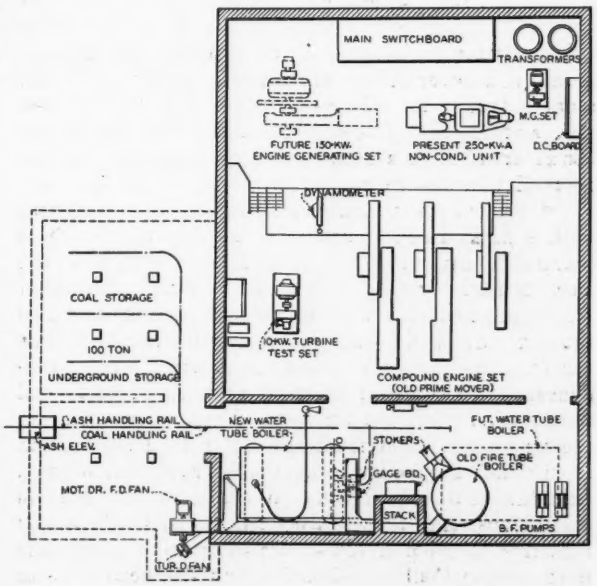


Fig. 1. Plan of power plant, Worcester Polytechnic Institute

fan is dampered and the position of the damper under the control of an A. W. Cash hydraulically operated damper positioning device which is sensitive to changes in steam pressure. The control for this fan is of the drum type and is conveniently mounted on the wall in the firing aisle. In addition to a motor driven fan a small turbine driven fan is installed discharging into the same ductwork, the exhaust steam from the turbine discharging into the exhaust steam main.

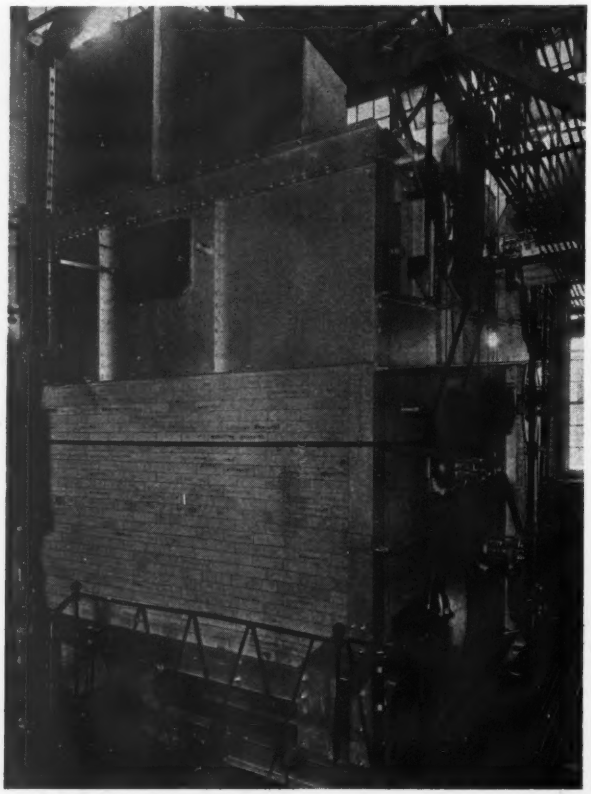


Fig. 2. Boiler superstructure finished in firebrick and aluminum paint

The usual criticism of an educational power plant is that the power boilers are not as a rule available for student test work. More often than not an excellent power plant is available for light, heat and power, but for student test work only a second grade small boiler is available, and of course is not equipped with the usual accessories which are provided on the power boilers. This plant was laid out so that all the usual testing facilities will be available on the new boiler. For checking water fed to the boiler, a calibrated Venturi meter is installed in the feed line, while weigh tanks are available for occasional 48-hr. tests. In this case the feedwater is taken from the storage condensate returns tank by a small centrifugal pump and fed by level control to an elevated tank directly above the weigh tank and from the latter to a surge tank from which the boiler feed pumps draw their supply. In addition to the above, an orifice with upstream and downstream taps has been installed in the steam lead from the boiler for future connection to a steam flow meter. Coal is weighed on an overhead type of beam scale as the coal bucket is being brought up to the boiler front and records kept of the net weights on a log.

Instruments to Guide Operation

For a guide to operation of this heating system, a central boiler gage board, as shown in Fig. 4, has been installed. The board is symmetrical about the center line and has duplicate instruments for the new boiler, and the second set is being used for the time being with the present fire-tube boiler. On the top row are two steam pressure gages and an electric clock. Immediately below are two two-element straight line illuminated Ellison draft gages, the one element showing windbox or fan pressures, and the second element indicating uptake draft. A CO_2 recorder of the Hays type with continuous record is mounted between the draft gages. Since only one boiler will be used at one time, two gas filter elements are installed and a simple matter of valving puts either boiler on the CO_2 recorder. In the next row are steam pressure and temperature recorders for permanent record of both of these important items.

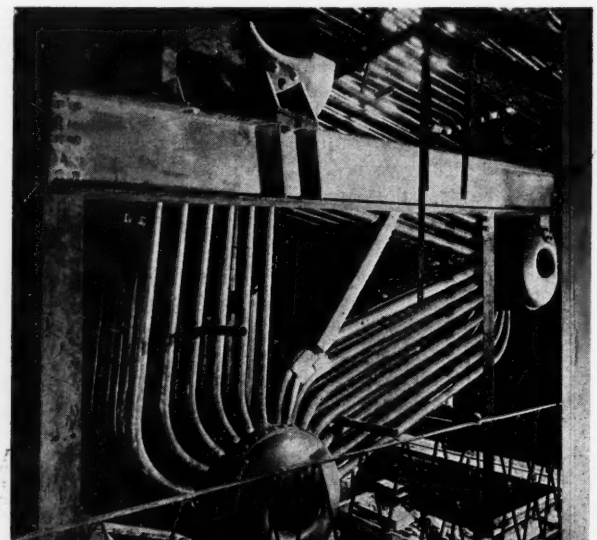


Fig. 3. View of boiler room during erection

The central recorder is of particular advantage to a heating system, for it gives a week's record of outdoor temperature on one chart. The lowest row contains two flue gas temperature recorders which are valuable as indicator of dirty boiler tubes.

Test Equipment

In addition, the boiler proper has provision for several test devices. A thermometer well is located in the top of the dry drum and provision is made for

attaching a test steam pressure gage to this drum. Several pipes are inserted in the setting wall in the first, second and third passes, as may be seen in Fig. 3, so that CO_2 gas samples can be withdrawn and analyzed with a hand Orsat set. Air flow connections are also provided at the center of the first pass, and in the third pass for future use in connection with a steam flow meter. The last pass has provision for CO_2, temperature or draft checking on both the aisle and firing sides of the boiler. It is expected that daily checks of boiler performance will be available from the various charts, and students will have the opportunity to make inspection of the boiler room during the college year in a course known as "Boiler Room Practice," and they will also have the opportunity of running regular duration boiler tests on a modern water-tube boiler. Incidentally the fire-tube boiler will be checked against the water-tube boiler in the matter of performance and students will have the benefit of first hand comparison.

Flood Lights and Meters

It should be mentioned that in connection with the rehabilitation of the boiler room, the lighting scheme has been changed to flood lighting at desirable points. In the remotely located buildings electrically driven vacuum return condensate pumps have been installed or will be installed. To check the steam distribution to each building, hot water condensate meters are being installed in each return line. It should, therefore, be possible to allocate the steam used to each building in much the same way as steam is allocated to the various departments of a large well managed factory and to maintain an indirect check on the amount of makeup feedwater.

In conclusion the plan of expansion and rehabilitation, shown in Fig. 1, is again referred to. At some future date, depending upon the condition of the remaining fire-tube boiler and the growth of load, a second boiler will be installed—a duplicate in capacity of the present new boiler. It is also planned to install shortly a reciprocating steam engine of slightly less capacity than the present steam turbine to carry low loads.

Principal Equipment Used in Boiler Room Rehabilitation

Boiler	
Manufacturer	Riley Stoker Corp.
Type	Four Drum Bent Tube
Heating Surface	2450 Sq. Ft.
Design Operating Pressure	175 Lb./Sq. In. Ga.
Steam Condition at Stop Valve	5 to 15° Superheat
Maximum Steam Generating Capacity	18,000 Lb./Hr.
Stokers	
Number	One-twin retort
Method of Operation	Steam Operated
Maximum Firing Rate	30.5 Lb. Coal/Sq. Ft./Hr.
Boiler Accessories	
Water Column	Yarnall Waring Co.
Safety Valves	Consolidated Ashcroft Hancock Co.
Number	Two
Blowoff Valves, Combination Type	Yarnall Waring Co.
Soot Blowers	Vulcan Soot Blower Co.
Number Elements	Five
Steam and Feed Piping	Washburn-Garfield Co.
Boiler Gage Board	
Type	Box Type
2 Steam Pressure Gages	Consolidated Ashcroft Hancock Co.
2 Straight Line Draft Gages	Ellison Draft Gage Co.
1 CO_2 Recording Meter	The Hays Corporation
1 Electric Clock	Warren Telechron Co.
2 Pressure-Temperature Recorders	The Bristol Co.
1 Outdoor Temperature Recorder	The Bristol Co.
2 Flue Gas Temperature Recorders	The Bristol Co.

This engine will then normally be connected to the exhaust steam system but for student test work will also be connected to exhaust into a surface condenser. Regular switchboard instruments with test blocks will be available for checking the water rate of the engine and a spare panel in the switchboard has been reserved for this future unit. Below is given the list of equipment and important data in connection with the present installation:

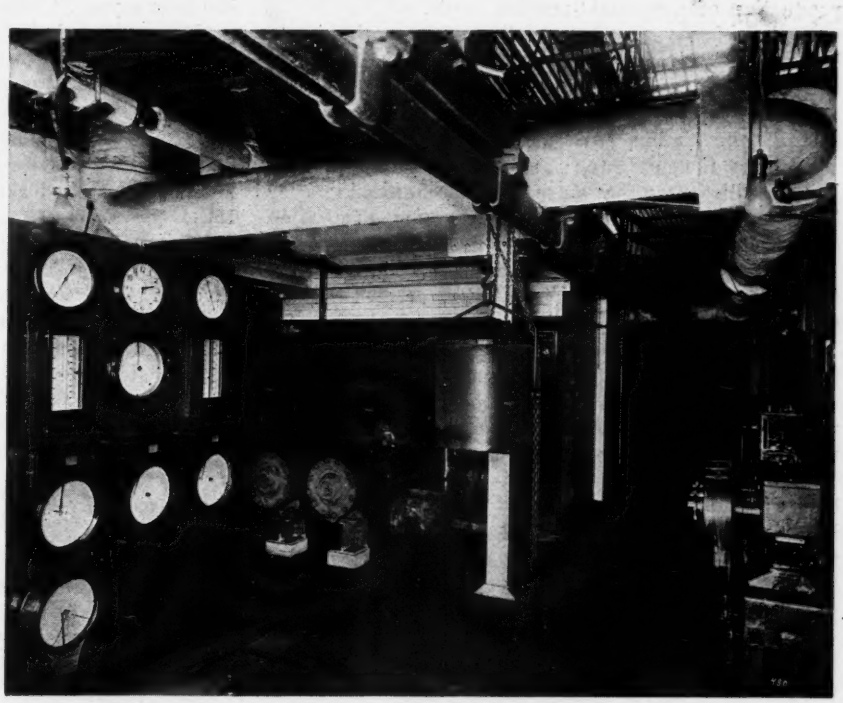


Fig. 4. Firing aisle shows a generation of progress in boiler room equipment

Alnico—A New, Powerful Magnet

RESEARCH in the field of permanent magnet alloys has resulted in a new alloy, Alnico, so much more powerful than those commonly used hitherto as to open entirely new fields of application for permanent magnets, it has been announced by the General Electric Company. Small motors, and various control devices hitherto operated by electromagnets can now use permanent magnet fields, at a considerable saving in cost and greater simplicity of construction; and Alnico already has been applied in a variety of applications, including blow-outs for relays, holding-in magnets of large switches, in latching and special timing relays, and in different control devices. Alnico magnets will lift about 60 times their own weight, when designed for that purpose.

The new alloy is usually a cast material and is finished to shape by grinding. Alnico generally should be cast in quantities for commercial applications, and is not available in standard bars for individual fabrication. The Simonds Saw and Steel Company of Lockport, N. Y., has been licensed by the General Electric Company to manufacture and sell these magnets.

Less than a quarter of a century ago the best known magnets were of hardened plain carbon steel, developed by cut-and-try methods. By metallurgical methods it was later found that the form of distribution of the iron-carbide in hardened steel was one factor that determined its quality as permanent-magnet material. Consideration was therefore given to the properties of alloy steels in which the alloying metal elements, other than iron, would form carbides. Thus the chromium and the tungsten magnetic steels were developed. The addition of cobalt to the tungsten-iron-carbon alloys resulted in another advance in the production of permanent-magnet steels.

Only a few years ago an alloy of iron, aluminum, and nickel was discovered to possess suitable permanent-magnet properties. This alloy contains no carbon and belongs to the precipitation-hardening type of alloys, quite distinct from the steels. The addition of cobalt was the next step; and thus was born Alnico. With the discovery that a precipitation-hardening alloy may possess excellent permanent-magnet properties, an entirely new field of alloys for magnets was opened.

The coercive force is higher and the residual induction lower for Alnico than for other magnetic materials. The maximum available energy is higher for Alnico, and occurs at a lower flux density and a higher demagnetizing force. Alnico magnets may, therefore, be of smaller volume but generally should be designed with greater cross sectional area and shorter length to maintain a given magnetic field in an external air gap.

Alnico magnets are less subject to demagnetization by stray fields. Tests on Alnico bar magnets resulted in a decrease in total flux of less than one per cent after being subjected for one minute to an alternating field of 100 amp. turns per in., and a decrease of approximately 10 per cent after being subjected to an alternating field of 500 amp. turns per in. No further decrease was observed when the alternating field was maintained constant for one-half hour.

Alnico magnets are less subject to demagnetization by high temperatures, and are less subject to demagnetization by mechanical vibration. Vibration tests on Alnico bar magnets resulted in a decrease of less than one per cent in total flux after severe vibration at 120 cycles per second for one-half hour.

Alnico magnets require a considerably stronger magnetizing force to magnetize them completely than do other magnet materials. A magnetizing force of at least 2000 oersteds (4040 ampere turns per inch) should be applied.

The new magnet alloy has a relatively low specific gravity (6.9), is non-corrosive, and is brittle. It is cast in the proper design, and finished by grinding. Any necessary holes should be cored in the casting. Soft steel inserts may be cast in for fastening.

Waterside Station

TO CARE FOR A HEAVILY increased demand for alternating current service in the midtown section of Manhattan Island, The New York Edison Co., Inc., will immediately begin a novel project for the modernization of its Waterside generating station, situated at 40th Street and First Avenue. An expenditure of about $5,000,000 is contemplated which will make Waterside one of the most economical power plants in the country, according to Frank W. Smith, President of the company. Under company policy, all new electric load is supplied by alternating current.

"By installing two new high pressure boilers and one new generator with exhaust steam passing through existing low pressure turbines, we shall have an efficient and highly economical generating station," said Mr. Smith. "We estimate that the rate of fuel consumption will be reduced to approximately half the rate now prevailing in the station. By reason of this new installation we expect to be able to reduce the fuel consumption of our electric system by about 100,000 tons a year."

It is expected that the work of installing the new equipment will be completed about April, 1937.

Waterside is one of the older generating stations in The New York Edison system. It now has 146 boilers of 5,256,000 lb. of steam total capacity per hour, and 19 generators of 376,200 kw. capacity. This equipment was installed at various times between 1900 and 1924.

Thirty-six of the existing boilers in the station and three of the present turbo generators will be retired. Two new boilers will be installed, each having a capacity of 500,000 lb. of steam an hour at a pressure of 1500 lb. a square inch, and a temperature of 900 deg. F. The steam from these new boilers will be used to operate a new 50,000 kw., 60 cycle turbo generator. The steam will exhaust from the machine at 200 lb. pressure, and will then pass through existing low pressure turbines to the condenser, generating an additional 65,000 kw.

The boilers will be equipped with the most modern fuel burning apparatus. There will be an elaborate system for thorough cleaning of the gases which result from combustion. A feature of the improvement will be a new smoke stack for the station 450 ft. high, which will discharge the chimney gases at a point above the neighboring high buildings.

This article on the uses of Aluminum in the power plant should be of interest not alone because of the importance this metal occupies in industry but because the month marks the 50th anniversary of the discovery of the Hall electrolytic reduction process by which it is manufactured today. Once a rare costly metal it has become one of the most useful metals in industry outside of steel.

Uses of ALUMINUM *in the Power Plant*

By T. W. BOSSERT
Assistant Chief Metallurgist
Aluminum Co. of America

ALUMINUM, now so frequently used in electrical transmission, was not always the common commercial metal it is today. It is one of the youngest of metals, and during the first 60 yr. of its existence, from the date of its discovery in 1825 to 1885, it was extremely costly. This was not due to the rarity of the metal, for aluminum is the most abundant metal in the earth's crust, but to the process of reduction in which a number of expensive chemicals were employed.

Some of the greatest scientists of their era worked on the problem of finding a way to make aluminum inexpensively. Though considerable progress was made, it remained for Charles Martin Hall, a 22-year-old graduate of Oberlin College, to develop the electrolytic reduction process, still in use today. His discovery was made just 50 yr. ago this month, and from it dates the commercial history of aluminum.

Development, slow for the first few years following Hall's discovery, progressed rapidly. Today, aluminum may be found in almost every industry. By alloying and strengthening the metal through various processes, it was able to serve a multiplicity of purposes. Many uses for it were found in power plants, its high electrical conductivity in combination with light weight and its great durability being responsible for many applications in this field.

Aluminum Busbar

Aluminum busbar has met with considerable favor in power plants because of its definite economy and versatility. It can be obtained in solid round and tubular forms, and in flat bar and channel sections. Each form has its own place in busbar construction, but with the trend toward heavy current, 60-cycle apparatus, the need for the most efficient busbar is definite.

The tubular bus has the most efficient form for transmitting alternating current; however, temperature rise is the controlling factor in bus design, and were it possible to ventilate the inner surface of the tube conveniently, its value would be greatly increased. A split tube would produce this added efficiency but it is structurally unpractical.

Buses constructed of parallel flat bars of aluminum, with ample air spaces between, are efficient and economical for many installations; their weight in aluminum being only 40 per cent of their weight of copper. In order to approach the efficiency of the split tube conductor, two structural aluminum channels are placed so that they form a hollow square and are spaced to allow internal ventilation. This design retains the advantage of flat surfaces and has a rigidity approximating that of a structural box section. This type of conductor is called "channeluminum" and the bars are made in the standard structural channel sizes.

Aluminum busbar has a high degree of resistance to atmospheric corrosion whether in rural, industrial, or sea coast localities. It also resists the corroding atmosphere of storage battery rooms. Because of this property, many plants are now employing bare aluminum busbar in place of lead-coated or painted copper conductors.

Clamps for aluminum busbar can be similar in design to those used for copper. They are made of high strength aluminum alloy economically, and match the conductor in weight and appearance. They have the advantage of being non-magnetic, and therefore they are standard items with some manufacturers for all busbar construction.

Closely associated with many busbar installations, is the problem of enclosure design for heavy current buses. Metallic housings are utilized for this purpose, and aluminum, being non-magnetic, serves especially well. The light weight, pleasing appearance, and adaptability of aluminum are all advantageous. One concern manufactures a metallic enclosure unit consisting

Fig. 1. Aluminum bus feeding furnaces, showing aluminum switch plates for disconnecting the furnaces.

of a steel back with insulators and busbar clamps attached, aluminum sheet forming the other three sides.

Aluminum Transmission Lines

The history of aluminum transmission lines began about 1898, but it was not until 1908 that the present type of aluminum transmission cable was invented. It is known as "A.C.S.R.," this abbreviation standing for Aluminum Cable, Steel Reinforced. The cable is composed of a core of steel wire, either single or stranded, with a sufficient number of aluminum conductor wires stranded around the steel core. More than 430,000 miles of this cable has been installed in the United States. A.C.S.R. is used on 84 per cent of the circuit miles of all 220,000-v. transmission lines in the United States and Canada and it is much used on all distribution and transmission lines from the high voltage lines to the 2300-v. rural lines. Its use for many years on rural line work has broken the way for the present activity in this field.

The widespread use of stranded aluminum cable is due to its high strength-to-weight ratio. Hard-drawn aluminum wire, such as is used in A.C.S.R., has a conductivity approximately 61 per cent of the International Annealed Copper Standard. For equal capacity, aluminum wire requires 59 per cent greater cross-sectional area than copper but weighs only 48 per cent as much.

The steel core of A.C.S.R. has about 50 per cent of the total strength of cables of the common types of stranding. Thus, any flashover or accidental damage to the surface of A.C.S.R. does not reduce its strength to the same extent as it would in an uncored cable. The high strength-weight ratio of A.C.S.R. permits the use of long spans and a minimum number of supporting towers. A single span nearly a mile long was erected in California between hill tops, flanked by a 3600-ft. and a 2200-ft. span. The combined length of the three spans is more than two miles.

Aluminum Parts in Electrical Apparatus

The large variety of aluminum alloys available covering a wide range of mechanical properties are extensively used for many of the individual parts of power plant equipment. The success of these parts may depend on one or more of the general characteristics of aluminum alloys such as light weight, high thermal and electrical conductivity, their durability in industrial atmospheres, pleasing appearance, or it may depend on some special property of one particular alloy.

In large rotating machinery, the advantages of aluminum conductor wire are being investigated, but only experimental units have been built. In Europe more progress has been made and several high-speed alternators have been built with rotor windings of thin flat aluminum bar. American manufacturers, however, have limited themselves to the auxiliary electrical apparatus of power plants.

Several good examples are to be found in motor design. Most of the conducting squirrel cages of the rotors of the smaller industrial induction motors are now cast from aluminum and aluminum alloys. The casting consists of short circuiting rings and bars and may also include the fan. Another concern winds the rotor coils of synchronous motors with aluminum wire to improve starting characteristics. Bearing caps of aluminum alloy have high thermal conductivity for rapid removal of heat from bearings. Aluminum brush holders have been used because permanent mold castings were cheaper than machined holders. These motors

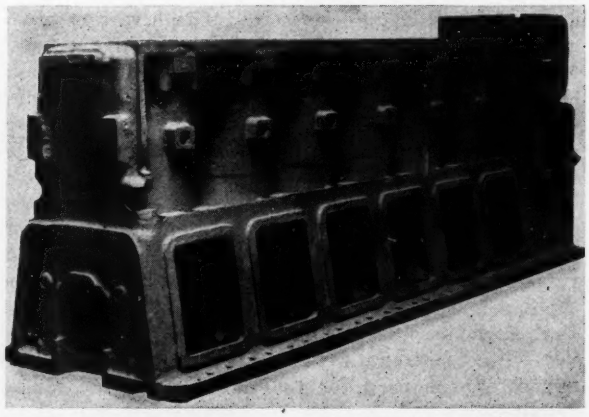


Fig. 2. Upper half crankcase and cylinder block of Diesel engine. The approximate weight of this cast aluminum section is 2380 lb. The section is 10 ft. long, 3 ft. wide and 4 ft. high.

were for railroad use so the reduction in weight was an added advantage. Some aluminum wire is also used for the solenoids of lifting magnets to reduce their weight.

Aluminum has given excellent results as a material for switchboard panels because it is light, strong, non-fragile and not bulky. It is non-magnetic and may have a variety of attractive finishes. Aluminum alloys are used extensively for meter boxes and housings because of their resistance to atmospheric attack and the fact that many designs can be die-cast very cheaply. Aluminum conduit is non-magnetic and has an exceptional life. Contactors are made with strong aluminum alloy arms and armature housings to reduce the inertia of moving parts, thereby permitting more rapid operation. Name plates and dial faces are still other examples illustrating the diversified usefulness of aluminum in power plants.

Diesel Engines

In Diesel engines the operating conditions are such that aluminum alloys can be used to great advantage. The extremely high compression and high temperatures reached in the combustion chambers of Diesel engines impose certain limitations in performance which can be overcome only by increasing the heat-dissipating capacity of the engine and reducing the bearing loads by the reciprocating and rotating parts. The aluminum alloy pistons and cylinder heads used in Diesel engines have a much greater thermal conductivity than many other commonly used metals. Aluminum cylinder heads are free from scaling and their use also results in a minimum carbon deposit in the combustion chamber and in improved exhaust valve and spray valve operation. Bearing loads are decidedly reduced through the use of aluminum alloy pistons and crankpin bearing boxes.

The crankpin end of the connecting rod exerts considerable force on the bearings because of its centrifugal action. In one case it was found that 35 per cent of the total crankpin work was the result of the centrifugal forces. The advantage of using light aluminum alloy crankpin bearing boxes in this case is obvious. In Diesel engines, such as those used in transportation, weight saving assumes double importance, and it becomes desirable and economical to make bedplates, crankcases, bolster castings and housings of aluminum alloys. In fact it is possible to build Diesel engines in which 70 per cent of the weight is aluminum.

The design of the other large stationary machines in the power plant, such as turbines and steam engines, includes the use of light aluminum alloys for reciprocating parts as connecting rods, crossheads and large cover plates which are often removed. Aluminum tubing is often made into fuel and oil lines because it is inexpensive and it successfully resists the attack of the sulphur compounds in the oil. Large numbers of blowers are manufactured with aluminum alloy impellers for reduced inertia and for quiet operation.

Architectural and Associated Uses

The utilization of aluminum in the architecture and decoration of the power plant building is similar to that in other industrial buildings. Here aluminum is used principally because it is not affected by the attack of industrial atmospheres. It is cast into spandrels (spandrels are the large ornamental castings occupying the vertical space between windows on the exterior of the building) because it lends itself readily to modern architectural design. Washed down by wind and rain, aluminum salts from aluminum spandrels do not stain adjoining masonry. Aluminum alloy extruded shapes of any required cross-section are extensively used for window frames, sash, doors, grilles, railings, treadplate, gratings, barbed wire and chain link fencing.

Excellent lighting reflectors, with a reflectivity up to 80 per cent, are made from aluminum sheet which is either polished or etched, depending on whether a specular or a diffuse surface is desired. An even greater reflectivity, far higher than that of most industrial reflectors, may be obtained from Alzak reflectors, made from aluminum sheet which has been electrolytically brightened. The protective coating thus produced is resistant to atmospheric attack in industrial communities, and when dirt and grime have dulled the brightness of these reflectors, they can be restored to their former intensity by an application of soap and water.

Aluminum paint has long been used in power plants for both interior and exterior applications. The properties of aluminum paint, durability, moisture-proofing, high reflectivity, opacity and resistance to attack by industrial fumes and gases, are generally recognized. Aluminum paint is the standard finish for the majority of transmission line towers and other exposed structures at central and substations. Interior lighting efficiency is improved by a coat of highly reflective aluminum paint. It is valuable for use in boiler rooms because it reduces heat radiation losses from furnaces and steam lines. Aluminum foil is also used, and with better results, for heat insulation, particularly for steam lines.

Boiler Water Treatment

Interesting results are derived from the scientific use of sodium aluminate for treatment of boiler feedwater. Sodium aluminate is used in conjunction with the established lime and soda ash process for water softening and can be used either in the water softening plant or directly in the boiler. One of its principal functions is the formation of a flocculent precipitate to coagulate the fine particles of calcium and magnesium hardness precipitated by the lime and soda ash treatment. If these particles are not coagulated, settling and filtration difficulties are encountered and they are carried into the boiler, they cause foaming and increased blow-down losses. A chemical reaction between sodium aluminate and magnesium, which is present in small quantities in all waters, results in the formation of magnesium aluminate, the desired flocculent precipitate. The magnesium aluminate floc also acts as a nucleus for the lime and soda ash reactions thereby accelerating the process and insurging a degree of softening not feasible without it.

Some boiler scales have been found to consist primarily of calcium or magnesium silicate. Silica, which is responsible for this scale, is not removed by ordinary lime and soda ash treatments. By the proper use of sodium aluminate, the two forms of silica (colloidal and soluble) are largely eliminated. Colloidal silica is physically removed by coagulation and soluble silica

is chemically removed through the formation of calcium or magnesium aluminum silicates which are non-scale forming flocculent precipitates. Sodium aluminate indirectly assists the phosphate after-treatment necessary for high pressure boilers by furnishing a softer and better clarified water.

Production and Consumption

In the production of aluminum by Hall's electrolytic process, at least 10 kw-hr. of power are required for every pound of aluminum produced. Each year enormous amounts of power are consumed by the aluminum industry, and, as a matter of fact, it consumes more electric power than any other single industry in this country. On the other hand, one of the largest consumers of aluminum is the electrical conductor field, and the potential developments of aluminum in the power plant promise to make future consumption even greater.

Preventable Accidents

By Mark Bell

SOME TIME ago an anonymous correspondent wrote the editor of an engineering magazine. He had been boiler draftsman for a marine company which had recently turned out six boats, similarly constructed. Going over his figures one evening he was horrified to find that, in one of the important calculations, he had made an error that cancelled the safety factor.

By some miracle this error had escaped the notice of the chief draftsman and the engineering superintendent and it was only after the ships had been commissioned that he had discovered it. What should he do? If he confessed he would probably lose his job. If he kept quiet, perhaps nothing would happen but the possibility that a serious accident might occur would always be present.

My first voyage at sea took me to Calcutta where we were moored in the stream. I was sent up to close the deck steam valve and, as was natural, went out on deck to have a look around. Leaning overside I saw a native boat right below me and the whole family was clustered around a large bowl of rice curry. I had a wheel wrench in my hand and, carelessly, I relaxed my hold on it and it fell smack into the bowl which broke into bits and spilled the food. The din that followed was tremendous. Not only had I spoiled a meal, but I had defiled the family, their boat and their chattels by letting my infidel wrench drop into their sacred boat. Other boatmen took up the tale and after the captain had restored order by lavish distribution of "baksheesh," which was deducted from my wages, I had received a lesson which I have never forgotten.

Another incident follows that also occurred in India. A junior engineer was sent up to close the main stop valve on a boiler. He must have been very green because he had jammed a length of pipe on the end of his wheel wrench to give him leverage. The boiler had a head of pressure on it and the cover fractured. The facts of the tale will never be known because he did not live to tell them, but I am sure his conclusion would have been as follows: Always consider that such a piece of equipment is designed to take care of both ordinary and extraordinary conditions and don't try to overstress equipment at risk of life or limb.

Only a few years ago on a large passenger liner, an engineer was sent to grind in the valve on a fan. Carelessly, he did not check up to verify whether the steam carried at 100 lb. pressure was shut off at the header. He removed all the nuts from the studs and, to loosen the cover, struck it a blow with a hammer. The header valve was open and the cover blew off. He had several ribs crushed, was seriously scalded and spent many months in the hospital.

I served on a tramp steamer that had an evaporator bolted to the bulkhead about 10 ft. above the engine room plates. When we scaled the copper coils inside it, our custom was to lower it to the floor with a small rope falls. On a freighter new stores are hard to get and the rope was badly frayed. We kept using it just one more time but this one time it broke. The copper coils fell the 10 ft. and curled up like a flapper's hair and it took us days to straighten them out.

In the plant where I was apprenticed there was a capstan in the yard which was used to drag coal cars. The man who operated this was employed in the blacksmith's shop and wore an apron. He had been told countless times to remove it before turning on the capstan steam valve. He never did and, sure enough, the last time he used it his apron caught and he was dashed against the wall and killed.

One large passenger liner on which I served had doors between the low pressure turbines and the condensers. These doors were closed by hydraulic power from an outside station. A friend of mine was working in the condenser directly below one of these when some clown outside operated the closing lever. The door dropped on his hand, holding him fast. He could not make anyone hear by shouting and it was an hour or more afterwards when he was discovered, during which time he had suffered terrible pain. He lost several fingers and his nerves are completely gone. Of course he should have tagged the outside lever and put a wood block under the door to hold it up but, although he was an experienced engineer, he had not done so.

Years ago it was the custom in England and on the Continent to have young boys scale the Scotch boilers, because they were able to get around the confined spaces more easily. On one vessel the work was being pushed along hurriedly as the vessel was due to sail. As soon as the boys had crawled out, the doors were replaced, the boiler filled and the fires lighted. All was hurry and bustle and, quite some time after it was found that one boy was missing. His remains were found in the boiler where he apparently had been asleep and had not heard the call of the chargehand. This terrible accident was an isolated case but I cannot imagine a more ghastly death.

The incident impressed itself upon me. Whenever I have cause to work in a boiler I always remove one of the manhole covers to the store and lock it up. This ensures that any excessive heat I suffer will be after death and not before.

Europe's Largest Extraction Turbine in Russia

By Rene W. P. Leonhardt

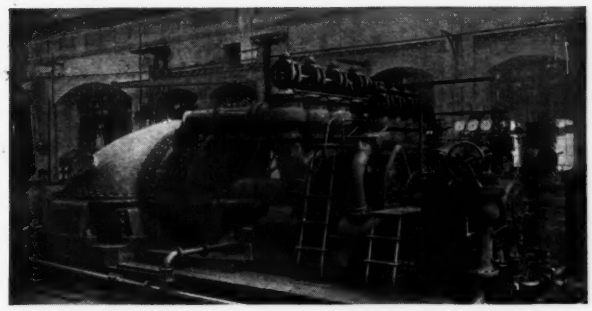


Fig. 1. One of the 24,000 kw., 3000 r.p.m. turbines designed for 400 lb. 800 deg. F.

ECONOMIC ADVANTAGES of the coupling of power and heat is generally known yet it is seldom completely accomplished due to the difficulties which stand in the way. It is seldom possible to achieve the necessary balance between power and heat demand so the extraction turbine with a condensing plant is the nearest solution to the problem. Without intending to praise the Russian system of planned economy, it must be pointed out that the Soviets utilize all the possibilities of a methodical combination of power and heat, one recent development using extraction turbines with outputs of 24,000 kw. with 150 tons per hr. (330,000 lb. per hr.) of controlled extraction, the largest of the kind ever built in Europe.

The large "Kusnezkstroi" power station and steelworks which was supplied with three 24,000 kw. extraction condensing steam turbines is situated about 50 miles from the coal and ore mines in Kusnezbecken near Prokopiewsk (south of Nowosibirsk) southwest Siberia, will have three of these units for driving three-phase alternators of Russian make. Apart from the above turbo-sets which are each rated for the extraction of 150 tons per hr. of steam (maximum), the power station also accommodates two 6000 kw. condensing turbo-sets. One of these latter sets supplies the necessary energy for the auxiliary equipment of the station, the other acts as a standby.

The three 24,000 kw. sets are chiefly intended for supplying the steelworks proper and the ore depository in Telpes and Mundibasch, situated about 45 mi. away, as well as the neighboring Prokopiewsk and other collieries, which require about 20,000 kw. About 75 t. of the 100 t. of extraction steam normally required are for warm water preparation at a pressure of about 128 lb. per sq. in. ga. for the four boilers of the steam power plant which are fired by pulverized-fuel, oil or blast furnace gas. The remaining 25 t. are used at a pressure of 28.5 lb. per sq. in. ga. for heating purposes and for driving a few smaller machines.

The large 3000 r.p.m. turbines are designed for 28 atm. ga. (400 lb.) and 400 deg. C. (750 deg. F.) normal or 425 deg. C. (800 deg. F.) maximum temperature; and for a condenser water inlet temperature of 15 deg. C. (59 deg. F.) The output of 24,000 kw. can be attained with maximum, as well as with no, extraction.

Conversion of the high pressure drop is effected in one impulse control stage and the 10 following impulse stages. The low-pressure portion has 4 impulse stages the last of which has a pitch circle diameter of 1800 mm. (70.87 in.) The rotor blades of the last stage have a length of approximately 400 mm. (15.75 in.) and are designed as so-called twisted blades in order to allow for the change in the peripheral velocity and to obtain over the whole length smooth admission into the rotor blades. The first 7 diaphragms are cast in steel, and their blades are milled all over. The remaining diaphragms are made of high-class special cast-iron with cast-in blades. Governing is effected by an Isodrom control device which influences the high and low pressure valves in the same sense at constant extraction and changing load, and in the opposite sense at constant load and changing extraction, without the speed governor needing to act in the latter case. The advantage of this system lies in allowing the quantity of extraction to be changed without varying the power output.

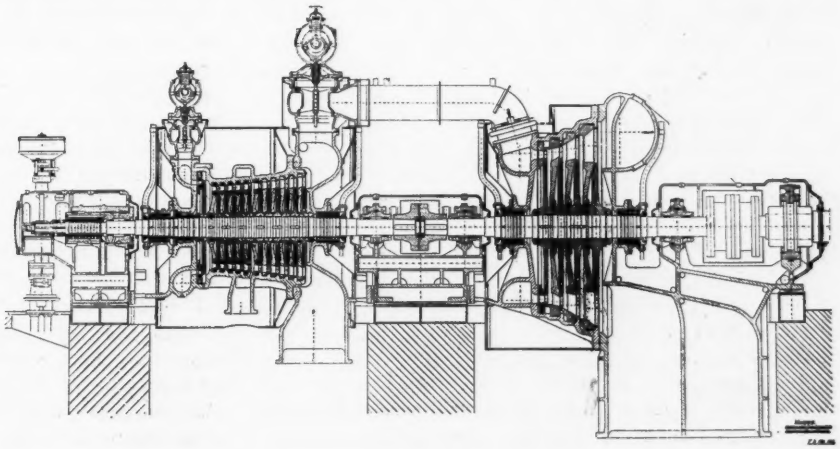


Fig. 2. Cross section of the turbine designed for a maximum extraction of 330,000 lb. per hr. of steam. The turbine will deliver full load from zero to full extraction

Curing Steam Governor Troubles

A little thought and care will usually do the trick. By BUNYAN KENNEDY

STEAM GOVERNORS depend upon centrifugal force for their operation; usually the change in position of two, or more, rapidly whirling balls being utilized to move a valve and permit more or less steam to enter the steam chest so as to maintain the desired speed. The valve is cage-like in its structure and in small sizes may be suspended from a brass stem with the seat located in the governor base. If the stem moves upward when the governor balls are pushed apart (or upward) with the hands, the valve moves upward to cut off; if the stem moves downward under such manipulation, then the valve moves downward to limit the amount of steam entering the chest. But this matters little, since what applies to one governor in eliminating trouble usually applies to another; a bit of common sense is all that is required to overcome all the exceptions to fixed rules.

If a governor doesn't function steadily under a steady and normal load, there is something wrong. The fault may not be in the governor itself, but the trouble should be located and eliminated. Intermittent "kluk-kluk-kluks" are easily detected by the ear. How can the cause of the trouble be located? First, determine if the governor belt is slack. If slack is found, make the belt reasonably tight. If the trouble persists after making the belt reasonably tight, see if there is a bump of any sort where the belt is joined together. An efficient workman prefers to check the governor for minor causes of trouble before tearing into the mechanism.

If the trouble continues after giving the joint the necessary attention, then determine if the governor is making the number of revolutions per minute specified by the manufacturer. If the governor's speed is lower than that specified, then you must put on a governor drive-pulley of greater diameter or increase the diameter of the one you already have by some method. In short, the speed of the governor must be increased. On the other hand if you find it impossible to get sufficient engine speed after running the speed screw up to the limit, then the governor is being driven too fast. However, you aren't apt to encounter trouble of the kind referred to in the last two instances, unless you are using an engine which is not equipped with the kind and size of governor specified by the manufacturer. Manufacturers test engines before putting them on the market, and it is wise for the consumer never to accept anything but standard equipment.

Next Try This

We shall suppose that you have checked up on those matters mentioned above, making corrections where necessary, and that the same kind of trouble persists, even after using the "speed screw" freely and wisely. What should be done next? It has been my experience that the next thing to look for is looseness of the valve on the stem. After long use some valves become "loose" between the two nuts on the lower end of the stem, due to constant vibration. Looseness at that point renders the valve less sensitive, making it unresponsive and causing the governor to work jerkily. In other words, the stem has to move farther than normally necessary to make the valve open or close and this makes the governor act too late. If the stem moves far without moving the valve, the governor may be rendered so inefficient as to permit the engine to run away, due to failure of the valve to close sufficiently.

It appears that a governor valve could hardly become loose, since the lower stem nut is usually held in position by inserting a wire into a hole through the stem and nut. The wire prevents the nut from moving in either direction on the stem, and apparently there would be no tendency on the part of the nut above the valve to work upward. I know from experience, however, that valves do become loose occasionally and, since most of the wear after becoming loose, is on the upper side of the lower nut and on the under side of the upper portion of the valve, it is usually necessary in eliminating such looseness to place a thin washer between the lower nut and the valve. This puts the valve back into its original position with relation to the valve stem as shown by the accompanying sketch.

This method eliminates the necessity of shortening the valve stem to make the valve work as effectively as it did before becoming loose. Nothing is more important in a governor than the length of the valve stem, since the length must be such that the valve will be almost closed or fully open when the action of the governor balls is such as to correspond with either extreme. It is rarely ever necessary to use a washer at the point indicated by "A" in the sketch because in the absence of a cotter, the upper nut can usually be moved in either direction. A washer can be used to advantage here, however, if the threads are worn off the stem. Such a procedure enables one to tighten the nut in good threads.

Where to tighten the valve after it wears loose

Since the wire fastener in the lower nut prevents the latter from being moved for adjustments, the method suggested above is practical and satisfactory because a very fine

adjustment in "raising" or "lowering" the valve on the stem can be attained by selecting a washer of suitable thickness. (It must be understood that the wire fastener is used in the lower nut to prevent the latter from working off and allowing the valve to drop off into the steam chest.)

If All Efforts Fail

Application of the above suggestions seldom fails to make a governor work satisfactorily, but if they fail proceed as follows: First, be sure that the valve is properly set to open and close, and working in unison with the balls. You may check this by measuring the distance the valve stem moves when the balls are moved (by hand) from one extreme to another, and then by comparing this measurement with the distance between the cut-off point and the valve when the governor is idle, allowing the governing mechanism to rest on the edge of the governor base (for height accuracy) when taking the measurements.

While one man holds the mechanism, another manipulates the balls to determine if the valve movement and position correspond with the valve seat in the base. Once secure, I believe it is a bad idea to tamper with movable valve seats, since they are easily damaged. If you find the valve properly set, next see that the valve stem is perfectly straight and is not packing-bound. It is hardly necessary to state that worn or defective parts must be replaced. Don't get the idea that all troubles can be cured by turning the adjusting speed screw. No matter what the text has led you to believe, remember that governors don't cut the steam entirely off unless the governor belt breaks and the idler (if there is one) drops down. The speed at which a governor should be run is usually marked in a conspicuous place on the frame.

An inertia governor is suitable where the load is steady, but is too slow to pick up where there are sudden and great increases in the amount of power required. Where load conditions fluctuate appreciably, a spring type governor is much more desirable, because the short stall is avoided by the pep and sensitiveness of such a mechanism.

Thorough lubrication is necessary to prevent a governor from vibrating excessively and becoming wabbly before it should. A normal governor doesn't grumble or have fits when operated under normal conditions.

Floods—Magnitude and Frequency

An addition to the available basic information regarding flood characteristics of rivers in the United States is presented in a report just issued by the United States Geological Survey, Department of the Interior, as Water-Supply Paper 771, "Floods in the United States—magnitude and frequency." The Geological Survey prepared the publication in collaboration with the Water Planning Committee of the National Resources Board and its predecessor, the Mississippi Valley Committee. Essential flood data are listed for some 200 river-measurement stations selected with regard to geographic distribution, length and reliability of record and comparability of physical conditions. May be obtained from Supt. of Documents, Government Printing Office, Washington, D. C. Price $1.00.

Over-Compounding D. C. Generators in Parallel Without an Equalizer

It is a well known fact that if two over-compounded d.c. generators are to be operated in parallel it is necessary to make a separate connection called the equalizer between the armature terminal of one machine to which the series field is connected and a corresponding terminal on the other machine. If this connection is omitted the operation will be unstable and one machine will take more than its share of the load and eventually, if proper circuit breakers are not inserted, will drive the other machine as a differentially compounded motor. While this instability has been well known, the cause of it has not and several theories for it have been advanced.

This question of paralleling over-compounded generators without an equalizer was the subject of a paper presented recently by John Miles and Joseph Palm, students at the Michigan College of Mining and Technology, at the Great Lakes District meeting of the American Institute of Electrical Engineers at Purdue University, October 24 and 25.

In this paper the authors reviewed the theory advanced for the unstable operation of generators in parallel without an equalizer and then described a series of investigations which had been made at the Michigan College of Mining and Technology to determine the relative correctness of the theories involved. This investigation involved both a mathematical as well as an experimental consideration of the problem. The mathematical investigation, however, proved rather futile because of the extreme complexity of the problem and it was finally abandoned. The results of the experimental investigation, however, are of considerable interest for they prove that two generators could be operated in parallel without an equalizer when certain specific conditions were fulfilled. The conclusions reached by the authors of the paper are as follows:

1. Two d.c. generators, both over-compounded, could be operated in parallel without the use of an equalizer if it were possible to keep the equalizer current always at zero—that is, if there were no potential difference at any time between the two points to which the equalizer is connected.

2. The machine which would tend to take all of the load will depend entirely upon which direction the equalizer current would flow at the instant when the unbalance occurs, were there a closed circuit through the equalizer.

3. With the two generators which were used in the experiment and which were driven by d.c. motors, an increase in speed of one machine, all other conditions being balanced, caused that machine to take all the load and eventually drive the other as a motor. The speed of the generator taking all the load would fall off again after its original rise.

4. While it cannot be definitely stated without further proof, it is believed that the above conditions will be true for any such generators, provided they are over-compounded enough so that either machine operating alone will increase its terminal voltage with an increase in load, providing no effort is made to change torque produced by the prime mover of either machine to keep the speed of the machine constant.

COMBUSTION CONTROL

Part XII. Air Operated Control of the Bailey Meter Co.

WHEN DESIGNING A PLANT which is to be controlled automatically over wide ranges, it is important to select major equipment having flexible control characteristics. This is advisable since the range in boiler rating over which automatic control is effective is limited by the control characteristics or possible speed variations of fans, fuel feeders, pulverizers, burners and stokers. Individual boiler plants vary widely in respect to these equipment details as well as to size, construction, fuel, load and operating conditions but the fundamental principles of good combustion apply to all and a combustion control system must be sufficiently flexible to be readily adaptable to any plant.

This problem has been solved in different ways by different manufacturers, the Bailey Meter Co. having two systems to meet the individual preferences of power plant engineers and the economic demands of the complete range of sizes of boilers from 200 hp. up. The first and oldest is the electric system designed primarily to meet the needs of the central station for control with interlocks between factors such as fuel and air, to insure uninterrupted operation under unusual conditions together with full flexiblity at all times. This system will be described in a later article. The second system is of the air operated type designed to meet the economic needs of the industrial plant and smaller central station. It offers a simple, yet flexible and complete control at a lower cost and will be described below.

Both systems utilize the same fundamental principles; that is, the control of fuel and air by steam pressure, readjustment of the fuel-air ratio by the steam flow-air flow meter and maintenance of balance between forced and induced draft by furnace pressure. Differences in the two systems are in the method of carrying out the adjustments called for by the measuring and controlling elements, the pressure controller, the boiler meter and the furnace draft controller.

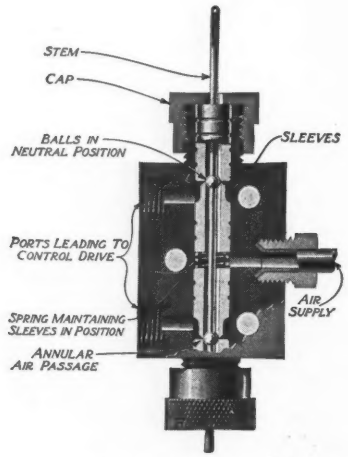


Fig. 1. Cross section of the air pilot valves which play an important part in the Bailey system. The double acting pilot valve may be converted to a single acting valve by plugging one outlet port

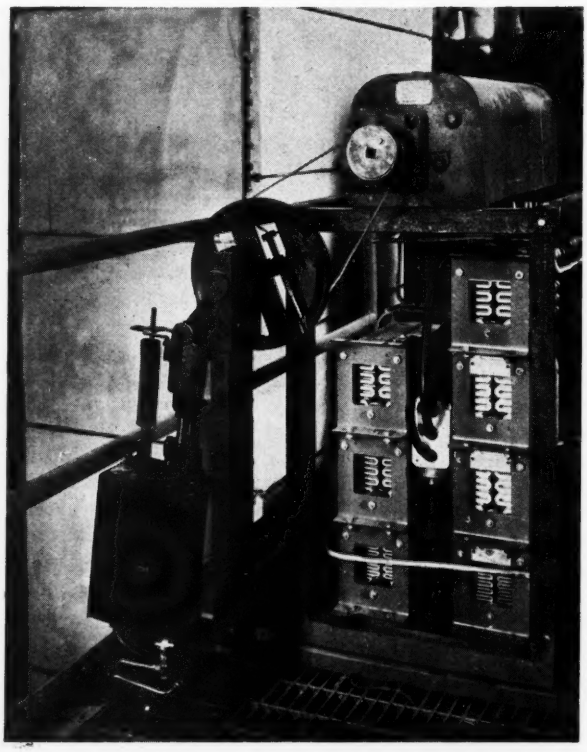


Fig. 2. Control drive as installed for regulating an induced draft fan motor controller

A diagrammatic layout of the air operated control system as applied to a stoker fired boiler is shown by Fig. 3. Stoker fired boilers being more responsive to changes in air supply, the arrangement in this case is the regulation of air supply from steam pressure and fuel from the boiler meter as shown. The master pressure controller, responsive to pressure changes in the steam header, controls all boilers in the plant through the master air pilot valve. This controller is of the usual Bourdon helix type with an adjusting sector by which the pressure of all boilers may be raised or lowered as desired. In practice, the controller is usually made of the recorder type, mounted in a case with two small pressure gages, one showing the air supply pressure, the other the air pressure in the control system commonly referred to as the loading pressure.

In operation the system works as follows: An increase in load would cause a proportional drop in steam pressure which actuates the master controller to reposition the master air pilot valve and increase the loading pressure. This increase in pressure is directed through the master selector valve and the up-take draft selector valve (on each of the individual boiler panels) to a metal bellows on the uptake draft control drive. The increase in pressure expands the bellows and displaces the relay pilot valve so as to admit air pressure to the operating piston and open the damper an amount proportional to the change in control pressure. The pilot valve is returned to neutral position by means of the spring and yoke shown in the drawing, the tension of the spring being increased as the piston rod moves upward.

As the damper opens the furnace pressure tends to drop, but this change is immediately detected by the diaphragm type furnace draft regulator which moves to open the forced draft damper and maintain the furnace draft constant. This increased flow of air through the boiler results in an increased differential across the points F-S and this differential connected to the air flow side of the boiler meter, is used as a measure of the air flow.

As shown by Fig. 3, the pilot valve for the stoker speed control is actuated by both the steam flow and air flow. The linkage is designed so that the pilot valve will have, for every value of steam flow (when the pens are together) a definite position which determines the loading pressure sent to the stoker control drive. If the pens are not together the pilot valve will be displaced from its normal position in a direction to bring them together by changing the stoker speed. Thus if the air flow rises above the steam flow, indicating excess air, the stoker will be speeded up so as to maintain the desired ratio.

Stoker speed is regulated by a drive unit similar to that used on the uptake damper. The furnace draft is maintained by an oil-sealed bell or large sensitive diaphragm drive. In the diaphragm type, as in Figs. 3 and 4, linkage from the diaphragm moves the pilot valve to control the movement of the piston. Motion of the piston repositions the pilot by means of a chain, diminishing or adding to the counterbalance weight until the pilot valve is again in its neutral position. If it is desired to have the furnace draft subject to either manual or automatic control, an oil sealed bell and standard control drive are utilized and a selector valve added to the individual boiler panel.

These selector valves, Fig. 5, provide the flexibility of the system, allowing either manual or automatic control and collective or individual adjustment. One selector valve is provided for the master panel. With the transfer knob in hand position, the output of all boilers may be governed manually using the right-hand pressure gage as an index. Variation of this gage from 5 to 25 lb. as affected by turning the adjustment knob, represents a variation in plant output from minimum to maximum. Individual boiler panels may also be furnished with selector valves for those factors of which flexibility of operation is desired, for example,

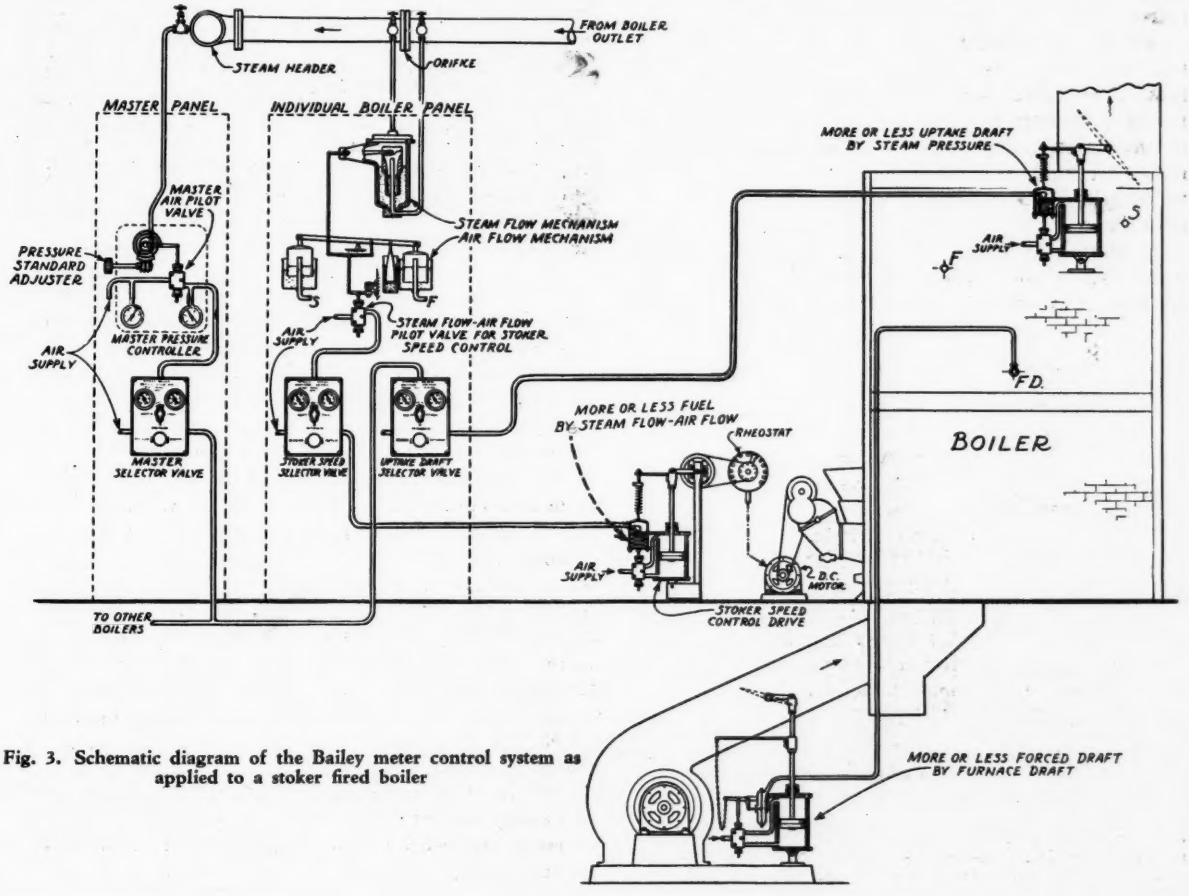
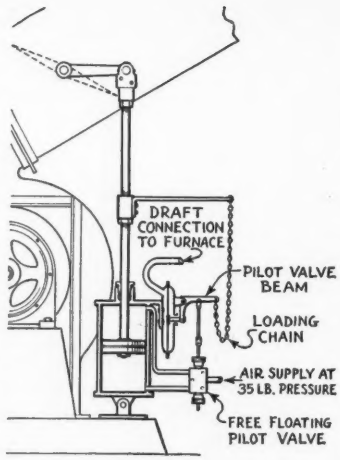


Fig. 3. Schematic diagram of the Bailey meter control system as applied to a stoker fired boiler

Fig. 4. Diagrammatic arrangement of draft controller



This controller measures furnace draft with a large sensitive diaphragm, the movement of which actuates an air pilot valve admitting pressure to one end or the other of a drive cylinder until the damper position or fan speed has been changed sufficiently to restore furnace draft to the desired value.

For example, an increase in furnace draft and a corresponding slight movement of the diaphragm to the left, moves the pilot stem downward, admitting pressure under the piston, which in turn moves upward and opens the damper. This movement diminishes the weight of chain supported by the pilot valve beam until the diaphragm force is exactly balanced and the pilot valve is returned to its neutral position. The chain loading device provides a simple and accurate means of applying a counter force against the diaphragm which is finely graduated with the movement of the control drive. When this counter force exactly balances the force produced by the furnace draft on the diaphragm, no further movement of the controller occurs.

The Bailey draft controller may be applied either to the forced draft or the uptake draft as desired. It functions independently of other control equipment, requiring only compressed air and a draft connection to the furnace.

stoker speed and uptake draft. In this manner, each of these factors can be taken off automatic control and operated manually if desired.

On any of the selector valves, with the transfer knob in either hand or automatic position, the right-hand pressure gage is an index of the speed or position of the controlled factor. The left-hand gage indicates the loading pressure received at the selector valve from the controller.

With boilers fired by fuel in suspension, changes in the rate of steaming are made by changing the rate of fuel feed and air supply simultaneously from the steam pressure and correcting the ratio if necessary from the boiler meter. Equipment involved is the same as for stoker units although arranged somewhat differently (see Power Plant Engineering, p. 546, October, 1935, for a pulverized coal layout), so as to make the change simultaneously and, at the same time provide for the time lag in certain systems, for instance unit pulverizers where the time of the coal flow through the mill must be considered.

The air pilot valve shown by Fig. 1 is the heart of the system and is used in practically every individual piece of equipment making up the control. It consists of a balanced, frictionless, free floating stem with two balls of equal size controlling the air flow through ported sleeves. Air is admitted at constant pressure to the space between the two balls, which, being slightly smaller in diameter than the pilot valve sleeves, allow a small quantity of air to escape. This tends to prevent

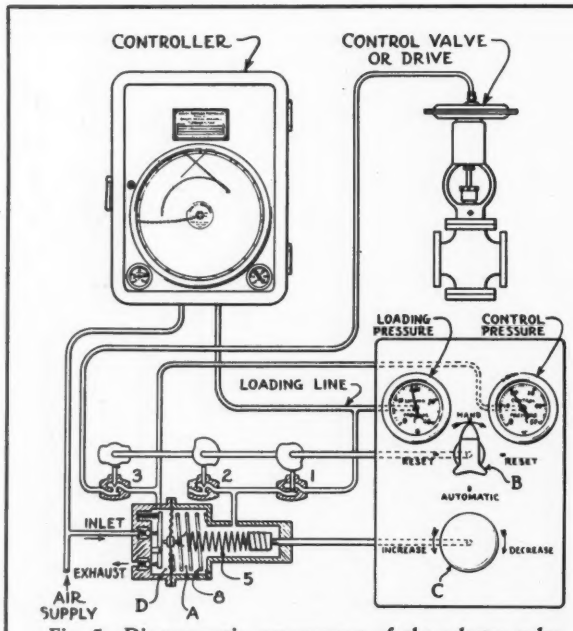


Fig. 5. Diagrammatic arrangement of the selector valve

This device, which gives flexibility to the system by facilitating change from one type control to another and allowing manual adjustment of individual equipment, consists essentially of an adjustable relay and a transfer valve assembly.

The relay valve consists of two chambers, A and D separated by a diaphragm. A tension spring 5 and compression spring 8 are provided as a means of loading the diaphragm. It can be seen by inspection that the force of these springs or the force resulting from the application of pressure to chambers A and D will result in a movement of the entire diaphragm assembly to operate the inlet or exhaust valve. If the pressures in chambers A and D are equal, and springs 5 and 8 are balanced to oppose each other, the unit is in stable equilibrium. Each change in controller loading pressure applied to chamber A will operate the inlet and exhaust valves to establish a corresponding change in pressure in chamber D so that the pressure in chamber A is definitely repeated in chamber D. This is normally the operating condition with the transfer valves in the automatic position.

If chamber A is open to atmosphere, the pressure in chamber D is dependent entirely upon spring loading obtained from the compression and tension springs. The variation in spring loading is obtained by changing the loading of the tension spring by rotating knob C.

MANUAL CONTROL—In the manual control position, shut-off valves 2 and 3 are open and 1 is closed. This valve arrangement disconnects the controller from the relay valve and vents chamber A of the relay valve to atmosphere. Manual control is obtained by turning knob C which varies the spring load on the diaphragm, to operate the inlet and exhaust valves to establish the desired control pressure. This pressure is indicated by the control presure gage.

TRANSFER FROM MANUAL TO AUTOMATIC CONTROL—Before transferring from manual to automatic control, knob C should be rotated until the control pressure gage reads approximately the same as the loading pressure gage, then knob B of the transfer valve is rotated clockwise to the reset position.

In the reset position shutoff valves 2 and 3 are closed and 1 is open. Shutting Valve 3 divorces the control drive or regulating valve from the selector valve so that its position is undisturbed during the transfer. This valve arrangement connects the controller to the upper side of the relay diaphragm (chamber A) which will operate in conjunction with the spring loading to increase the control pressure. The relay valve should then be adjusted by rotating knob C in the lower direction to equalize the pressures indicated by the loading and control pressure gages. When these pressures are equal, the transfer valve knob B may be rotated clockwise to the automatic control position.

AUTOMATIC CONTROL—In the automatic control position, shutoff valves 1 and 3 are open and 2 is closed. This valve arrangement connects the loading pressure from the controller to chamber A of the relay valve, which accurately reproduces this loading pressure in chamber D, to position the control drive or regulating valve.

LOAD ADJUSTMENT—If desired, the control pressure may be increased or decreased with relation to the controller loading pressure by changing the relay valve spring loading during automatic operation. Turning knob C during automatic operation, changes the relay valve spring loading to increase or decrease the control pressure established in chamber D proportionately. This load adjustment is indicated by the difference in loading and control pressure gage readings.

TRANSFER FROM AUTOMATIC TO MANUAL CONTROL—Before transferring from automatic control to manual control, the operator first observes the control pressure as indicated by the gage, and then turns knob B clockwise to the reset position, closing shutoff valves 1 and 3 and opening 2. This valve arrangement exhausts the pressure from chamber A of the relay valve to atmosphere, decreasing the control pressure gage reading. Since valve 3 is closed, control drive or regulating valve position is undisturbed. Knob C is then rotated in the "raise" direction until the control pressure is equal to the control pressure before starting the transfer from automatic to manual control. The knob B may then be turned clockwise to the manual control position.

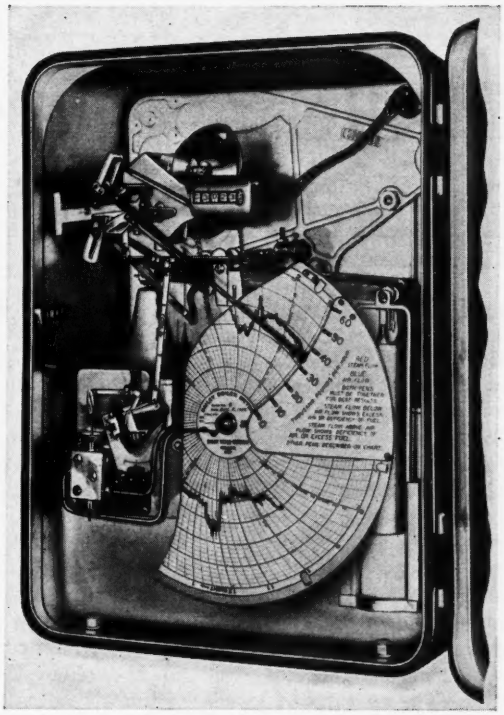


Fig. 6. The proper fuel-air ratio is maintained by the boiler meter arranged so that any change from the desired steam flow-air flow ratio gives a corrective force through the air pilot valve at the lower left of the case

actual contact between the balls and the sleeves and acts as a lubricant.

The pilot valve shown is of the double acting type used as a relay with the piston-operated control drive. The two outlets are connected to the control drive cylinder. When the pilot valve is in the neutral position as illustrated, the air pressure supplied to each side of the piston produces equal opposing forces and the piston remains stationary. Should the pilot be moved slightly in either direction, increased air pressure would be admitted through one port to one side of the piston and air would be exhausted from the opposite side through the other port.

To obtain a single-acting pilot valve such as required for use with the master and steam flow-air flow controllers, one outlet is plugged. Each position of the pilot valve stem will result in a definite pressure being set up in the outlet port varying between 5 and 25 lb. per sq. in. for full range movement of the pilot.

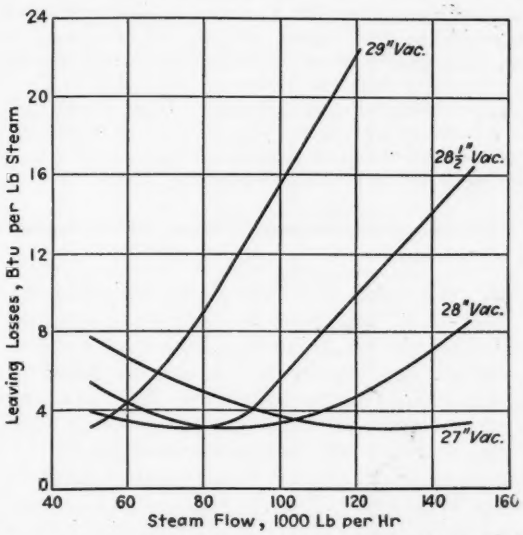
Clean compressed air at 35 lb. per sq. in. pressure is required for supplying the controller pilot valves and the control drive pilot valves. The source should be of sufficiently high pressure so that this value can be maintained at all times by pressure reducing valves.

A main air filter and pressure reducing valves are installed in the air supply lines to insure having clean dry air at constant pressure. Individual filters are also provided in the lines to and from each pilot so that any dirt which may be in the connecting lines will be prevented from interfering with the operation of the valve. The volume of air required is relatively small and may be figured approximately at 0.5 c.f.m. for each pilot valve and selector valve in the system.

Turbine Leaving Losses and Vacuum Corrections

BASED UPON THE ANALYSIS of steam flow through non-divergent nozzles with oblique exit faces, Linn Helander, head of the department of Mechanical Engineering, Kansas State College of Agriculture and Applied Science, presented at the A.S.M.E. Spring meeting in Cincinnati a procedure whereby steam-turbine vacuum corrections may be calculated with a fair degree of accuracy when the design characteristics of the last row of blades and one set of water rates for specified steam conditions and loads are known.

As outlined, the procedure was intended primarily for consulting engineers and power engineers and not for turbine engineers. On that account certain simplifying assumptions were introduced, which, although perhaps not acceptable where precise results are required, should be satisfactory for the purposes for which the formulas have been developed.



Characteristic leaving losses as calculated assuming conditions given in the text

The curves show characteristic leaving losses calculated by assuming the quality of the exhaust steam to be 88 per cent and the nozzle efficiency of incremental energy conversion in the last row of blades to be 90 per cent. The spouting area of the last row of blades was assumed to be 9.35 sq. ft. and the gaging was assumed to be 45 per cent.

In addition to a procedure for evaluating vacuum corrections, the paper gave simple formulas for evaluating small increments of isentropic heat drop when the expanding steam is saturated. These formulas give evaluations of small increments of heat drop more accurately than they can be read from ordinary steam charts and may be solved with little if any more labor than is used in reading charts.

Approximate formulas which express the specific volume and latent head of dry saturated steam in terms of the temperature of the steam were also presented.

New Laboratory Data Relative to Embrittlement in Steam Boilers*

By FREDERICK G. STRAUB[1] and T. A. BRADBURY[2]

Results of laboratory tests show that purified sodium hydroxide will not produce cracking of steel test specimens in short-time tests, whereas technical sodium hydroxide made by the lime soda process will. When the impurities present in the technical sodium hydroxide are added to the purified caustic and then used in tests, the specimens crack. It appears that when silica is present in sufficient amounts, along with the pure caustic, cracking will take place. However, when smaller amounts of silica and small amounts of calcium, magnesium and aluminum are added to the pure caustic, cracking will also take place. These results indicate that it is apparently necessary to have one or more catalysts present in the sodium hydroxide solution in order to cause cracking within a reasonable period of time.

FOR THE LAST 30 yr. the Engineering Experiment Station of the University of Illinois has been very much interested in the investigation of the cause and prevention of embrittlement in steam boilers. During the period between 1924 and 1930 extensive research was conducted on this problem. In the last year additional work has been carried on, and the following is a brief summary of the results obtained.

The steel tested was the regular flange steel referred to in Bulletin 216 of the Engineering Experiment Station, University of Illinois, and the apparatus was that described in the same bulletin. The previous work had shown that the steel test specimens cracked when stressed in contact with a concentrated solution of sodium hydroxide. In the present investigation the steel was spring loaded so as to have an average stress of 50,000 lb. per sq. in. in all tests, and the steam pressure in the bombs was held at 500 lb. per sq. in. gage. The composition of the caustic solution was varied. Samples of technical, U.S.P. and Reagent Grade sodium hydroxide made by different manufacturers, and by different processes, were tested. The amount of sodium hydroxide used in the solutions for the tests was a 20 per cent solution, or 250 grams per liter of water. When the technical sodium hydroxide made by the lime-soda process was used, the steel specimens cracked in the same time and manner as described in the work already reported (Table I).

When the Reagent Grade of sodium hydroxide (made by three different manufacturers) and the technical grade made by the electrolytic process were used, the specimens did not crack. Likewise, when U.S.P. sodium hydroxide, furnished by two different manufacturers, was used, no cracking occurred. In 1925 tests were made using U.S.P. sodium hydroxide, but cracking took place. This difference in behavior was considered as due to the presence of some impurity in the present-day technical and in the older U.S.P. caustic. The analyses of several technical and reagent grades of caustic sodas are given in Table II.

Various Grades of Sodium Hydroxide Used

Tests were then run to determine the cause of this difference in action of the various grades of sodium hydroxide. The difference may apparently be due to one or more of the impurities present in the technical caustics acting as a catalyst. It is also probable, however, that in purifying the caustic, an inhibitor has been added. If the first assumption is true, it should be possible to add the impurities present in the technical caustic to the purified caustic and cause the steel to crack. Tests were run attempting to do this. Thus carbonate, chloride, sulphate, silica, aluminum, calcium, magnesium, iron, manganese and copper were added separately to the reagent grade caustic No. 3, in amounts similar to their occurrence in the technical caustic which had caused cracking. The steel did not

Table I. Results of tests using various grades of sodium hydroxide. Specimen spring loaded to 50,000 lb. per sq. in., and the steam pressure held at 500 lb. per sq. in. gage. 250 grams of the sodium hydroxide to be tested was added to 1000 grams of water, and then added to the test bomb.

NaOH Used			Results of Tests
No.	Grade	Process of Manufacture	
1	Technical	Lime Soda	Crack
2	Technical	Lime Soda	Crack
6	Technical	Electrolytic	No crack
7	Technical	Electrolytic	No crack
8	Technical	Electrolytic	No crack
3	Reagent	-	No crack
4	Reagent	-	No crack
5	Reagent	-	No crack
9	U. S. P.	-	No crack
10	U. S. P.	-	No crack

* This investigation was conducted under a coöperative agreement between the Utilities Research Commission, Inc., of Chicago, Illinois, and the Engineering Experiment Station, University of Illinois, Urbana, Illinois. These results are released by permission of both parties of the coöperative agreement. Original presentation was made at the Annual Meeting of the A.S.M.E.

[1] Research Assistant Professor, Chemical Engineering, University of Illinois.

[2] Graduate Student in Chemistry, University of Illinois.

Table II. Chemical Composition of Various Grades of Sodium Hydroxide Tested in Per Cent

Sample No.	1	2	3	4	5	6	7	8
Grade	Tech.	Tech.	Reagent	Reagent	Reagent	Tech.	Tech.	Tech.
Form	Flake	Powder	Pellet	Stick	Stick	Powder	Flake	50% Soln.
Process of Manufacture	Lime Soda	Lime Soda	-	-	-	Electro-lytic	Electro-lytic	Electro-lytic
NaOH	98.6	98.0	98.0	98.9	98.0	94.0	98.76	50.00
Na_2CO_2	0.65	0.86	1.75	0.80	2.0	2.0	0.60	0.10
Cl	0.23	0.40	0.010	0.007	0.005	-	0.07	0.30
SO_4	0.24	0.05	0.005	0.007	0.005	-	0.068	0.001
SiO_2	0.20	0.28	0.020	0.015	0.020	0.02	0.02	0.005
Al_2O_2	0.008	0.006	-	-	-	-	0.002	0.0008
Fe	0.001	0.0006	0.002	0.0005	0.002	-	0.001	0.0005
CaO	0.006	0.023	-	-	-	-	0.002	0.0005
MgO	Trace	0.002	-	-	-	-	0.004	0.001
Mn	0.0002	0.0003	-	-	-	-	0.0001	0.00005
Cu	None	0.00001	-	-	-	-	0.0001	0.00005
Ni	0.0003	None	-	-	-	-	0.00002	0.00001

crack in any of these tests. Steel tested in between these tests, but using technical caustic No. 2, cracked in the regular manner. A sample of the technical caustic No. 2 was then prepared by making a 50 per cent solution of it with water, filtering to remove the precipitated impurities, and then making the test solution from the filtrate. Under these conditions cracking could be prevented. This appeared to indicate that the impurity, or impurities, causing the action may be precipitated from a 50 per cent solution, and that the difference in action is due to the presence of these chemicals.

A test was then run using reagent grade caustic No. 3, and adding to it the impurities present in the technical caustic in equal amounts. The steel cracked. Several more tests run under similar conditions also cracked the steel. Additional tests were then run in which the chemicals present were eliminated one by one. The final tests and the results obtained are given in Table III.

Silica Is Apparent Catalyst

The results of these tests appear to indicate that if any one chemical is added to the reagent grade caustic No. 3, in amounts equal to that in which it occurs in the technical caustic, it will not cause the steel to crack. If, however, the silica, calcium, magnesium and aluminum are all present, the cracking takes place. If the silica content is increased to an amount higher than that in which it occurs in the technical caustic, cracking takes place. These results might be interpreted to indicate that there are one or more chemicals which, if present along with the sodium hydroxide in sufficient amounts, will cause the cracking. The presence of caustic appears to be necessary, and the other chemicals apparently catalyze the reaction.

Table III. Results of tests using reagent and technical grades of sodium hydroxide, to which various chemicals have been added. Specimen spring loaded to 50,000 lb. per sq. in., and the steam pressure held at 500 lb. per sq. in. gage. 250 grams of the sodium hydroxide was added to 1000 grams of water and the other chemicals added to the solution, unless otherwise noted.

NaOH Used		Chemical Added as Per Cent of Total NaOH						Results of Tests
Grade	No.	SO_4	Cl	SiO_2	CaO	MgO	Al_2O_2	
Reagent	3	0.055	0.24	0.12	0.022	0.002	0.006	Cracked
Reagent	3	0.055	0.24	0.12	0.022	-	0.006	No crack
Reagent	3	0.055	0.24	0.12	0.022	0.002	-	No crack
Reagent	3	0.055	0.46	0.12	-	0.002	0.006	No crack
Reagent	3	0.055	0.24	-	0.022	0.002	0.006	No crack
No caustic		0.055	0.46	0.12	0.022	0.002	0.006	No crack
Reagent	3	-	-	0.22	-	-	-	No crack
Reagent	3	-	-	0.41	-	-	-	No crack
Reagent	3	-	-	0.57	-	-	-	Cracked
Reagent	4	-	-	0.23	-	-	-	No crack
Reagent	4	-	-	0.41	-	-	-	Cracked
Reagent	4	-	-	0.57	-	-	-	Cracked
Technical	5	-	-	-	-	-	-	No crack
Technical	5	-	-	0.22	-	-	-	Cracked
Reagent (100 grams)	3	0.083	0.72	0.19	0.033	0.003	0.008	No crack

If one or more of these chemicals accelerate the action of the caustic on the steel, the practical application of these data might be far-reaching. This opens up a new field of investigation which should aid materially in finding the fundamental action taking place, and the reactions which prevent its occurrence. All of these chemicals are present in natural waters in amounts sufficient to bring about this action in the average boiler, if sufficient sodium hydroxide is also present. Thus, if the sodium hydroxide content of a boiler water were 100 p.p.m. and the silica content were 0.6 p.p.m., or if there were present 0.12 p.p.m. of SiO_2, 0.02 p.p.m. CaO, 0.002 p.p.m. MgO, and 0.006 p.p.m. Al_2O_3, the cracking could take place. These amounts of the impurities are present in practically all boiler waters.

Research Being Continued

Further research is being conducted in order to obtain more data. In the meantime, the power plant operators may continue to follow the A.S.M.E. Boiler Code Committee's recommendations with a feeling of assurance, since no available data conflict with their recommendations.

Sodium Silicate and Embrittlement

By W. C. Schroeder* and A. A. Berk*

Sodium Hydroxide Concentrations at 250 deg. C. up to 25 to 50 grams per 100 grams of water do not produce any significant effect on the tensile load that steel specimens will sustain.

Additions of small amounts of sodium silicate to the sodium hydroxide greatly reduce the tensile load that can be carried.

On specimens subject to both tension and bending with a line of stress concentration the load that could be carried at 250 deg. C. was reduced from 65,000 lb. per sq. in. in water to less than 20,000 lb. per sq. in. in sodium hydroxide-sodium silicate solutions.

Microscopic examination of the specimens that failed in the sodium hydroxide-sodium silicate solution has indicated that one of the characteristic effects of the presence of the silicate was the production of a large number of fine, intercrystalline cracks in the metal near the fracture.

The failure to recognize the part played by sodium silicate in the embrittlement of steel and the use of sodium hydroxide solutions that contained from very little to relatively large amounts of sodium silicate has resulted in many conflicting data regarding this type of failure. With a knowledge of the action of the silica, it is now possible to correlate many of these data. Up to the present no explanation backed by adequate experimental evidence has been advanced as to the reactions that produce embrittlement. Considerable evidence is available to show that the hydrogen released by the action of the solutions on the steel is a very important factor. It is difficult, however, to see the exact part played by silica in such a process. It is hoped to be able to determine the mechanism of the reactions during further investigations.

*Research Chemical Engineer and Junior Analytical Chemist, Bureau of Mines, Rutgers, University, New Brunswick, N. J. The paragraphs above are the conclusions of a paper for presentation at the February meeting of the A.I.M.M.E. It is a report of work carried on for the Joint Research Committee on Boiler Feedwater Studies and is reported here because of its close relation to the work reported by Mr. Straub.

Essential Installation Features *of* Fuel Oil Tanks*

By JAMES O. G. GIBBONS

Fire, Flood, Heat and Cold Present Problems That Must Be Solved When Fuel Oil Tanks Are Installed to Serve Power Plants

BEFORE ORDERING steel fuel oil tanks it is well to ascertain whether there are any local requirements which govern their construction.

Generally it is sufficient that they conform to the Fire Underwriters Specifications, but this is not so in all cases.

The capacity of oil tanks will be governed to a large extent by the rate of oil consumption, but where oil is delivered in railroad tank cars, it is well to assume that deliveries will be made in not less than 10,000 gal. lots, in which case the capacity of the tank should be at least 15.000 gal. and 20,000 gal. is generally preferred, as this gives ample reserve capacity and does not add a proportionate amount to the cost of the installation.

In most localities, especially in the neighborhood of industrial cities, it is possible to obtain daily deliveries of fuel oil in road trucks, so in many cases the capacity of the tank need not be as great as that required for railroad deliveries. It is generally poor policy, however, to make the tank too small and it is better to install a tank which will hold at least a week's supply.

Underground Tanks

When tanks are installed underground, it is good practice to set them on a 6 in. concrete slab having at least the same length and width as the tank, but local requirements differ and sometimes concrete saddles are specified. A concrete slab makes a good foundation for the tank to rest upon, but it is rather difficult to understand just what good a few saddles are supposed to be.

As a rule 2 ft. of earth over the top of the tank is satisfactory, but some local authorities ask for more.

As fuel oil is lighter than water, it is seldom necessary to consider the possibility of settlement of underground tanks, but where the ground is wet, and water is found near the surface, the question of anchoring against flotation should be given the fullest consideration. A safe method of taking care of this, is to make the concrete slab under the tank about 2 ft. wider than the diameter of the tank, and the same length, and assume that an excavation of this area is filled with water to the top, or to the highest point to which the ground water will rise. Then figure the weight of water which the hole would contain after deducting the cubic content of the tank, or the submerged portion of it if the water is assumed not to rise to its top. This will give the maximum flotation.

Now add together the weight of the concrete slab, the weight of the empty tank, and the weight of the earth necessary to fill the hole up to ground level, and if these together equal the weight of the water which would fill the excavation we are perfectly safe against flotation, provided of course, that the tank has been effectively anchored to the concrete slab.

If the ground water is high, the above weight will not be sufficient unless the slab has been made very thick, so concrete should be placed over the tank until the difference between the weight of the concrete and the earth which it displaces, equals the deficiency.

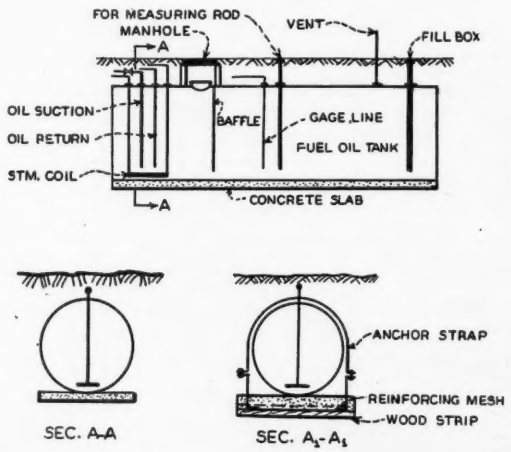


Fig. 1. Oil tank and pipe connections for underground installation

Where there is heavy traffic over the tank, it is well to provide a reinforced concrete pavement of somewhat greater area than the excavation, and in some cases this is required by the regulations, in which case the weight of the concrete will help to hold down the tank. It is well to provide concrete piers between the top of the tank and the underside of the pavement, so that the upward thrust of the tank will come directly on the concrete instead of upon soft earth.

Method of Anchoring

A good method of anchoring the tank is shown by the section designated at A_1-A_1 in Fig. 1, which also shows the general piping arrangement at the tank. The straps are shown fastened with lag screws to wood

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members which provide a convenient method of locating and holding them in place until the concrete is poured and set.

It may be objected that the method described for estimating the weight of the anchorage is unduly conservative but it has the advantage that it can be shown that it provides for maximum flotation conditions, and anyone is at liberty to deduct a certain percentage of weight if he thinks that the conditions warrant it. In fact this is a good method to follow in any event, as even if a certain percentage is deducted, the designer knows exactly what he is doing, and has located the limit of safety in accordance with sound engineering principles.

It is seldom either necessary or desirable to install more that one tank. It is sometimes claimed that two tanks should be provided so that one of them can be cleaned, but if the methods described herein for circulating and heating the oil in the tank are followed, it should not be necessary to clean out a tank more

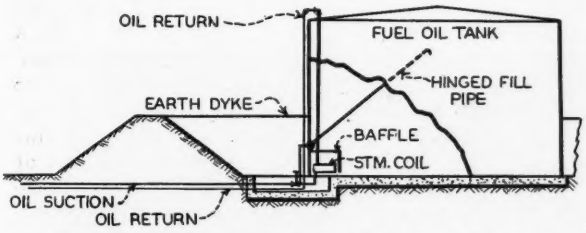


Fig. 2. Above ground fuel oil tank inside earth dyke

than once in 5 yr., and many installations have been in operation much longer than that without showing any indication that the tank will ever have to be cleaned. Multiple tanks add to the expense and complication of the installation, and seldom afford an equivalent advantage.

For comparative large capacities, underground concrete tanks are sometimes found to be economical. Fear is sometimes expressed that there may be considerable loss of oil through leakage, which might be true in the case of light oils, but in the case of heavy commercial fuel oils, there is really no danger of this because even if a crack develops, as soon as a small quantity of oil seeps through it forms with the earth an effective seal against continued escape.

The heating of the oil should be done locally, as described elsewhere, so the bulk of the oil in the tank will have comparatively low temperature and high viscosity.

Instructions for the design of concrete tanks are given in the Underwriters rules, and, of course, the principles of good concrete design should be complied with.

Where tanks are installed above ground, the same precautions should be taken to insure proper foundations, as would be taken in the case of other structures, and where the ground is marshy, it may be necessary to provide piling.

Baffles to Confine Heat

In steel tanks a baffle should be provided, preferably as shown in Fig. 1, unless other means are provided for confining the heat to the vicinity of the suction pipe, or the oil is sufficiently light to make heating unnecessary. Within the chamber between the baffle and the end of the tank, the heating coil, suction and return lines should be grouped. The baffle should extend to about 12 in. from the bottom of the tank as shown in Fig. 3 so that a man may crawl under it, and there should be sufficient leakage at the top to allow gas and air to reach the vent.

In the case of concrete tanks a shield should be installed around the suction and return pipes and the heating coil.

Other methods are available for confining the heat to the vicinity of the suction and return lines, such as surrounding the suction pipe with a steam coil, or providing a horizontal shield over the coil and the pipe, but in no case should an attempt be made to heat the main body of oil, unless the fuel is of such a nature that it tends to solidify in cold weather in which case only the minimum necessary amount of heat should be furnished to the main bulk.

When the bulk of the oil is heated, it not only wastes heat, but tends to cause the accumulation of deposits in the bottom of the tank, which cause trouble, and without which it would be seldom, if ever, necessary to clean out the tank.

If oil is kept in circulation around the heating coil, and is continually flowing through the suction and return lines, there will be practically no deposits, and everything burnable will be burned.

Tank coils for heating made of about 80 lineal feet of 1¼-in. steel pipe having an equivalent area of about 35 sq. ft., will be satisfactory. These can be made up with U bends.

The capacity of round steel tanks can be found as follows:

$D^2 \times 0.4896 =$ U. S. gallons per inch length.
$D^2 \times 5\frac{7}{8} =$ U. S. gallons per foot length.
$d^2 \times 0.0034 =$ U. S. gallons per inch length.
$d^2 \times 0.0408 =$ U. S. gallons per foot length.
D = feet. d = inches.

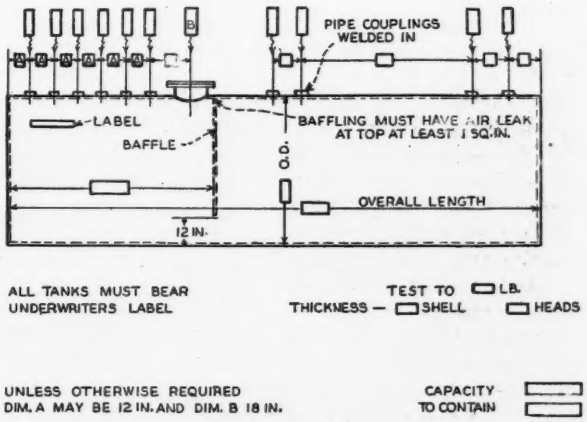

PIPE COUPLINGS WELDED IN
LABEL
BAFFLE
BAFFLING MUST HAVE AIR LEAK AT TOP AT LEAST 1 SQ. IN.
OVERALL LENGTH
12 IN.
ALL TANKS MUST BEAR UNDERWRITERS LABEL
TEST TO LB.
THICKNESS — SHELL HEADS
UNLESS OTHERWISE REQUIRED DIM. A MAY BE 12 IN. AND DIM. B 18 IN.
CAPACITY TO CONTAIN

Fig. 3. Typical dimension sheet for ordering oil tanks

for more exact capacities, tables provided by the manufacturers should be used, especially when heads are dished. In some localities dished heads are required by the local ordinances.

The manufacturers should be required to furnish a table giving the capacity for each inch of oil in the tank, so that readings can be taken with a measuring

rod. The opening in the top of the tank for the measuring rod should be 2-in. pipe size, and is preferably located as near as possible to the middle of the tank so that any error in leveling the tank will not greatly affect the readings. This of course also applies to the location of the indicating gage line.

The available indicating gages for showing the gallons of oil in the tank are seldom very accurate and sometimes get badly out of adjustment, so it is necessary to have some ready means for making a check. A rod graduated in inches, used with the chart above referred to, is the most reliable instrument for this purpose.

Figure 3 shows a typical dimension sheet for ordering tanks, the two outlets shown together near the center being for measuring purposes.

Fire Underwriters' Requirements

The following are some typical requirements of the fire underwriters, but a current copy of the complete rules should be obtained before the layout of the installation is complete. The mutual companies have their own rules which must be complied with if the property is insured with them.

Tanks for gravity feed must not be over 275 gal. capacity. Underground tanks to have 2 ft. of earth over top, or one foot of earth plus reinforced concrete slab not less than 4 in. thick extending 1 ft. beyond tank.

Unenclosed tanks inside buildings not more than 275 gal. each, or total of 550 gal.

Tanks enclosed inside buildings. Enclosures 6 in. concrete or 8 in. brick walls, bonded to floor. Enclosure filled with sand or earth, to extend 1 ft. above tank. Top to be 5 in. reinforced concrete or equal. In ordinary buildings, not over 5,000 gal. In fire resisting buildings, not over 15,000 gal., or in room cut off vertically or detached, two 25,000 gal.

Outside, above ground tanks, distance from building or property line.

750 gal.	5 ft.	64,000 gal.	50 ft.
1,100 gal.	10 ft.	80,000 gal.	60 ft.
3,000 gal.	20 ft.	128,000 gal.	75 ft.
21,000 gal.	25 ft.	200,000 gal.	85 ft.
31,000 gal.	30 ft.	266,000 gal.	100 ft.
45,000 gal.	40 ft.	400,000 gal.	150 ft.

For tanks permitted 50 to 175 ft. distance, the capacity may be increased 33 per cent if equipped with approved fire extinguishing system.

Between tanks:

18,000 gal.	3 ft.	24,000 gal.	5 ft.
48,000 gal.	10 ft.	75,000 gal.	13 ft.
100,000 gal.	15 ft.		

Above ground tanks subject to breakage or overflow (including standard steel tanks) to have embankment or dyke providing a lake of capacity not less than the capacity of the tank.

Flat section at top of dyke, not less than 3 ft., Slope 1½ to 1, both sides. Small tanks, 25,000 gal. and under, may be grouped in one dyke. Dykes must be continuous, no openings for pipes or roadways.

Masonry or concrete enclosures may be used instead of earth dykes, provided that they have the same capacity, and are satisfactory to the underwriters.

The method of installing a large steel tank inside an earth dyke is illustrated in Fig. 2.

Looking Forward Into the Past

Electrical engineers have a device which makes it possible to obtain an actual photographic record of a phenomenon which has already occurred, Dr. A. W. Hull of the General Electric Research Laboratory announced in his talk on "An Oscillograph with a Memory" at the autumn meeting of the National Academy of Science, at the University of Virginia, recently. "As quick as lightning" is no idle saying, for a flash of lightning requires very few millionths of a second; and yet laboratory workers can obtain a record not only of the lightning stroke itself but of the conditions immediately preceding the stroke—and obtain the record with the lightning stroke as the impulse to cause the photographing of the time even before it existed as a stroke.

"To study lightning one needs a device that is not only fast but can be gotten into action quickly," said Dr. Hull, "otherwise it misses the show completely. If the device were human, we would say it must have a short reaction-time. In recent years engineers have succeeded in developing lightning recorders with a reaction-time of less than a millionth of a second. Even this is scarcely short enough, however. The ideal would be a negative reaction time—a device which should have a premonition of when the lightning is going to strike, and begin recording ahead of time. Such a device would be able to report the whole story of events, before, during, and after the stroke.

"Impossible as it may sound, this feat has been accomplished. The new electric detective, the pre-recording oscillograph, may be depended upon to be on the job and ready with pencil and paper a twenty-fifth of a second before the lightning strikes. As its name indicates, is uses memory as a substitute for fore-knowledge. One makes sure that it does not miss the event by the simple ruse of putting it on the job long enough ahead of time—hours or months—with instructions to record continuously on its tiny slate, and erasing as fast as it writes, except for the last few lines. When at length the important event ocurs, another electric servant, this time a Thyratron tube with a magnet as an assistant, opens a camera shutter and takes a picture of the slate. The Thyratron tube does not have to hurry; a fiftieth of a second after the event is soon enough to open the camera. The lines written just before the event and not yet erased are photographed, and the camera is left open long enough to record also what is written during and after the event.

"The pre-recording oscillograph is a very simple device. The robot which writes the record is a cathode-ray tube; its pencil a beam of cathode rays; its slate a glass plate covered with a thin coating of willemite, a phosphorescent mineral which glows with a brilliant green light when the cathode rays fall on it, and which continues to glow for about a twenty-fifth of a second. That is the memory."

The device described by Dr. Hull at the Academy meeting is being used at Schenectady in the study by engineers regarding the life of power rectifiers, Thyratron and other electronic tubes. The times when the tubes will fail for one reason or another are unknown —the events are as unpredictable as is lightning—but the pre-recording oscillograph is sure to be on hand.

A Stitch in Time

Fig. 2. The second step—carefully applying the raw rubber to the exposed fabric prior to vulcanizing

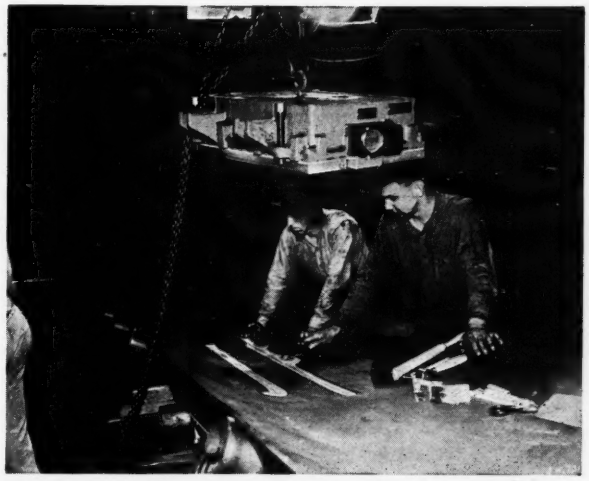


Fig. 1. The first step—cutting away the damaged rubber so as to expose and thoroughly clean the fabric

AFTER A PRELIMINARY RUN of ten years, during which it handled about two and three-quarter million tons of coal, the main coal conveyor of Columbia Station received first aid and is now ready to begin a real run for an indefinite period.

This station, belonging to the Union Gas & Electric Co. of Cincinnati, O., was dedicated on Dec. 10, 1925, and fully described in the article Columbia Power Station Serves Southwestern Ohio, on page 190 of the Feb. 1, 1926, issue of Power Plant Engineering. It was one of the first of our modern power stations and operates on a 550 lb. reheat-extraction cycle.

During the first year it set the almost unbelievable record for heat economy as first announced in the article Columbia Sets Record of 12,495 B.t.u. per kw-hr. by C. W. DeForest on page 181 of the Feb. 1, 1927, issue of Power Plant Engineering.

One of the main coal conveying conveyors used the 756 ft. Goodrich belt shown in the accompanying photographs. After this long period of service a few minor cuts are being repaired to make the belt practically as good as new and ready for an indefinite period of further service.

Repairs of this kind are not difficult but require careful workmanship and the portable vulcanizing unit shown. This is electrically heated and requires about 30 min. to cure the raw rubber used in the patches. Thus conveyor belts, disabled by the wear and tear of daily battle with coal, have a new lease on life.

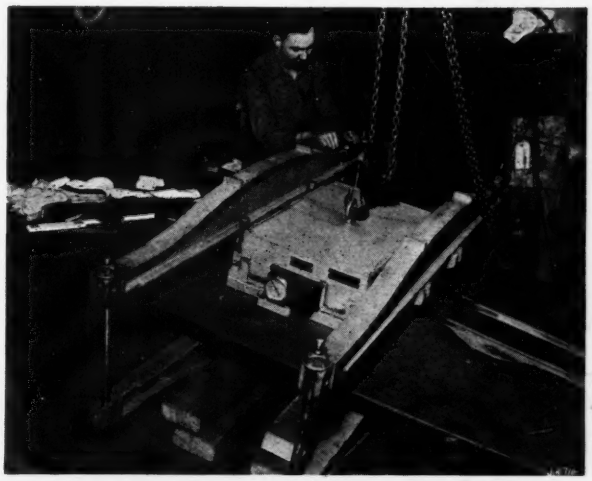


Fig. 3. The third step—applying the electrically heated vulcanizing press onto the patch for about 30 min.

Electron Tubes — Their

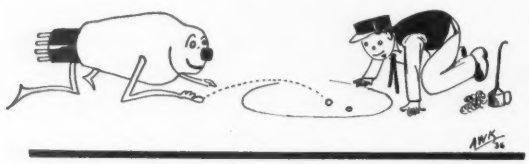
Part I. Preliminary Considerations. Fundamental electrical theory necessary to a proper understanding of the electron tube. Source of electron supply in an electric circuit. By A. W. Kramer

TO A YOUNGER GENERATION of technical men, grown to maturity since 1920, the vacuum tube and all that its name implies is less an object of mystery than it is to an older school of engineers who never saw the term "electron" mentioned in the text books of their day. These younger men have grown up with it, and therefore are familiar with its language and ways. But to others, the vacuum tube, despite its common use not only in the communication field but in industrial service as well, remains a thing of mystery—a delicate, fragile device—mysterious; not subject to the ordinary laws of electricity and not to be thought of along with other electrical equipment, switches, motors, relays, resistors and such things.

This viewpoint, of course, is purely mental. Actually, the vacuum tube in its fundamental character is no more difficult to understand than is the operation of a switch; indeed, as has been shown in recent years, the action of a switch in opening an electric circuit is an extremely complex thing and its understanding involves as much, if not a greater, knowledge of the physics of electrons and atoms as does the operation of the vacuum tube. Reduced to its fundamentals, the vacuum tube is a very simple device and its operation can readily be grasped by an intelligent child of twelve if properly explained.

In trying to understand the vacuum tube we must not associate it with the mystery of radio. Radio it is true is brought about by means of the vacuum tube but it does not enter into the mystery of electromagnetic radiation through space, no more indeed than does any other electrical device. The transmission of a person's voice to the far corners of the world requires not only vacuum tubes but also generators, batteries, resistances, condensers, relays, switches and countless other electrical devices with which all engineers are familiar and the vacuum tube should not be considered more mysterious than any of these devices.

Nor must the vacuum tube be thought of as a delicate, fragile device not suitable for use in power systems. Even the tubes used in our radio receivers are extremely rugged devices, even more so since they are being made entirely of metal. For power purposes their ruggedness compares favorably with most other electrical equipment, and in operation and maintenance they are in many ways, superior. Speaking of the experience of the American Gas and Electric Co. with electron devices over a period of 15 years, Philip Sporn, Chief Electrical Engineer of that company, said recently that most of the applications of these devices have proved superior from a performance and economic standpoint to heretofore existing methods over a wide range of operating conditions. They are reliable, economical and easy to maintain and replace.



THESE YOUNGER ENGINEERS GREW UP WITH THE VACUUM TUBE

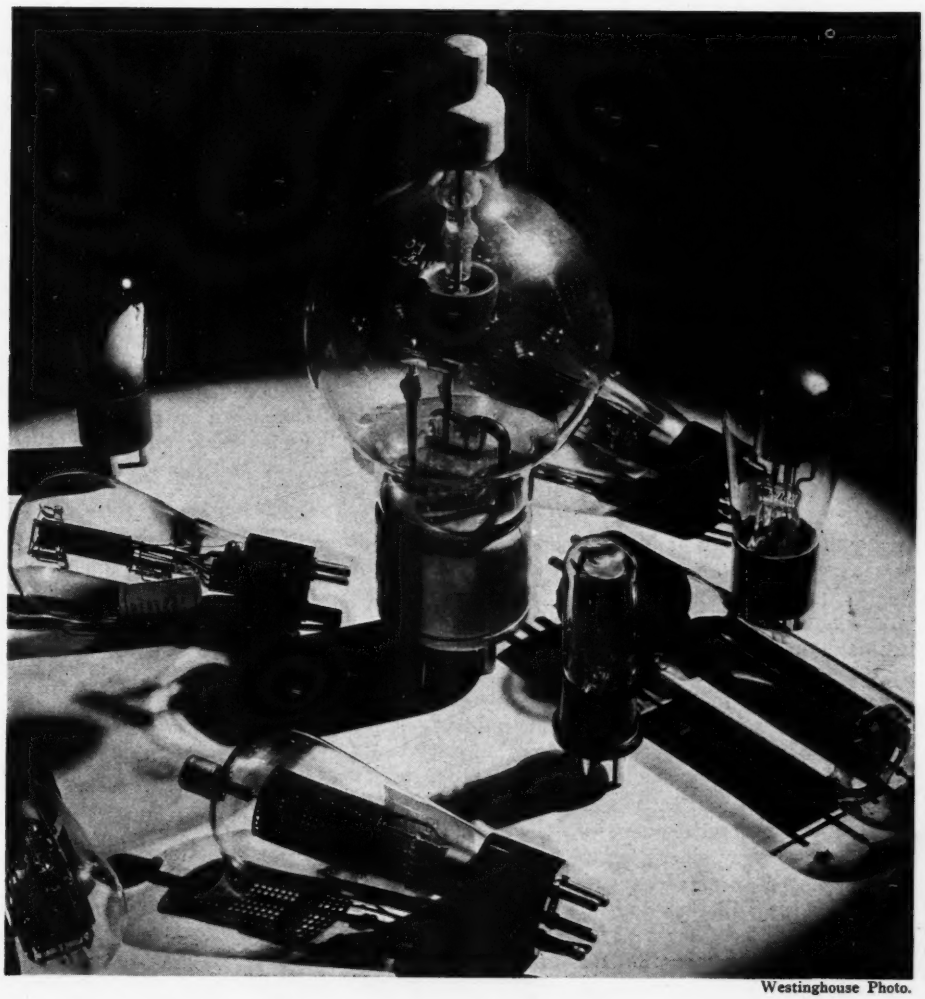
True, when considered in its complex forms and associated with intricate circuits the study of vacuum tube phenomena takes on all the difficulties and complexities that characterizes the advanced study of any subject but its fundamentals are just as easy to grasp as are those of an electric motor, in fact, they are simpler. They are simpler because in the vacuum tube we are dealing with electricity in its elemental form—with electrons and protons.

In a certain sense this is true of other electrical equipment as well because electricity, regardless of how or where we encounter it, is composed of electrons. That is, that which we call an electric current is nothing more than a stream of small negatively charged particles called electrons. Only in the vacuum tube, however, do we have the opportunity of studying these electrons *apart from matter* and that fact, more than anything else, perhaps gives the vacuum tube the astonishing properties it has.

Now, what is there that is so remarkable about the vacuum tube? In outward appearance, as we are familiar with it in our radio receiver, it appears little different from an ordinary incandescent lamp except that it gives only a feeble light. It is constructed of glass and metal parts and the fact that it is evacuated should not make it remarkable, for lamps have been evacuated for years. Furthermore, its structure, at least in the simpler forms, is simple. Fundamentally the vacuum tube consists of an incandescent filament and a metal plate mounted inside of an evacuated glass or metal envelope. The plate usually is connected to the positive terminal of a battery or generator and the filament to the negative terminal. Thus the filament is called the cathode and the plate the anode. Under such conditions, current flows in the circuit, the current evidently passing across the intervening space between the filament and the plate.

It is this last feature which gives the vacuum tube its remarkable properties—the fact that a current of electricity is able to pass across empty space. What

Principles *and* Application



Westinghouse Photo.

is the explanation of this action? In what way is the current carried across an empty space? And why is an incandescent filament necessary? For it can be shown that the instant the filament cools the current ceases, though the potential across the terminals remains as high or higher than when the filament was heated.

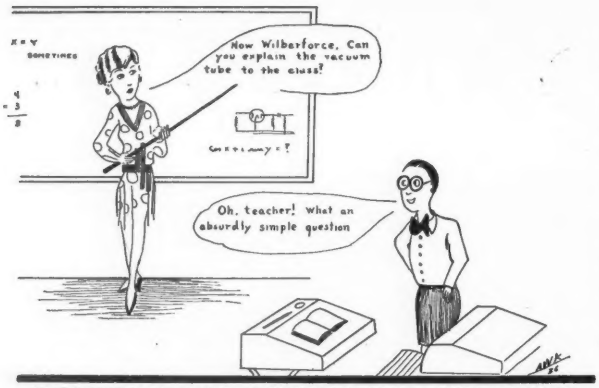
It is the purpose of this and succeeding articles to answer these questions—to describe simply and directly the action of and the principles upon which the vacuum tube operates. And when we use the term vacuum tube here we do so in its broad, popular sense; really we mean electron tube, for as will be shown, the vacuum tube is only one form of electron tube. So from now on, we shall refer to it as the electron tube.

But, why, you may ask, should the subject of electron tubes be of particular interest to engineers engaged in power generation? Granted, that certain industrial applications of them have been made, are they of sufficient consequence in the heavy power field to warrant the serious attention of power engineers?

Yes, most emphatically so! The electron tube is, by far the most important single device developed in the electrical field since the beginning of this century and sooner or later power engineers will find themselves confronted with the problem of applying and operating it in their work. The discovery of the control of the electron stream in the vacuum tube ranks in importance with Faraday's discovery of electromagnetic induction.

Forget that the electron tube had anything to do with radio—that it is associated with the mystery of sending energy through space. Think of it in terms of the most flexible, versatile and useful single electrical device ever developed, that it can be as useful to you in your work in the power or industrial plant as it has been to the radio and communication engineer. It is at once the fastest and most sensitive device man has ever made and it is available to do almost anything you may ask of it. It can reverse the motion of a white hot ingot weighing tons as easily as it can flip a coffee bean from a tiny conveyor. Its only limitations seem to be those of human intellect and ingenuity. It is silent, efficient and needs practically no attention. And fundamentally, its operation is simple.

Since an understanding of the electron tube can only be obtained if we understand something of the fundamental nature of electricity and matter, before we begin to discuss the electron tube itself, it will be



THE PRINCIPLES OF THE VACUUM TUBE CAN BE UNDERSTOOD BY AN INTELLIGENT CHILD OF TWELVE

to our advantage to consider briefly the nature of electricity and its relation to matter.

To begin with, it must be clearly understood that electricity is not a source of energy, any more than is water or steam or air. Like water or steam or air, however, it may be used to transmit energy and it is for that reason that it is sent over wires to far distant points. It serves as a "carrier" of energy and in our modern world that is all electricity is used for. Electricity flows through or in wires just as water and air flow through pipes. This sounds simple but is difficult to imagine, and, furthermore, it raises the question, where does the electricity used to transmit power in this manner come from originally?

When water is used to transmit mechanical energy from one place to another, in addition to suitable pumps, water motors and connecting pipes, a supply of water is required. This is drawn from some source of supply, a reservoir, a lake or well, or from the city mains, and forced into the system. Once the system is filled and provided there is no leakage, no more water is necessary since the amount contained in the system is used over and over again. The pump forces the water through the pipe line to the distant water motor or turbine, driving it, after which the water returns to the pump suction through return lines. No water is lost. With a compressed air system the action is similar except that in this case the air is not usually returned to the compressor by return pipe lines. Since the supply of air in the atmosphere is practically unlimited, air is merely drawn from the atmosphere by the air compressor at one end of the system and discharged back into the atmosphere at the receiving end.

An electric power system having a generator at one end and a motor at the other end is exactly the same as the hydraulic system. The generator may be considered as a pump used to pump electricity through the circuit. In this case, however, there is an essential difference and that lies in the fact that it is not necessary to fill the circuit with electricity when it is first set up. Why is this? Where does the electricity in the circuit come from?

The answer is simple but not obvious. It is that the electricity is in the circuit to begin with—an integral part of the structure of the material of which the circuit is made. It exists inherently in the conductors as "free electrons"—electrons which are not permanently attached to atoms of matter.

To explain this more clearly, we must consider briefly the structure of matter as it has been disclosed by the researches of modern physics.[1] All matter, regardless of the form in which we find it, is composed of atoms. The atoms of different elements (iron, copper, oxygen, etc.) differ from each other in certain respects but all of them are built along the same general principle. All atoms consist of a central dense core called the nucleus about which revolve one or more particles called electrons like a miniature solar system in which the sun represents the central core and the planets represent the electrons. As in the case of the planets, the electrons rotate about the nucleus in definite orbits. The nucleus carries a positive electrical charge and the electrons all carry negative charges. In the normal atom, the combined negative charges of all the electrons is exactly equal to the positive charge of the nucleus. Thus the normal atom, considered as a whole, exhibits no preponderance of either charge and is electrically neutral.

The essential difference between atoms of different elements lies in the different values of the positive charge on the core or nucleus. As this positive charge varies from one element to another, the number of

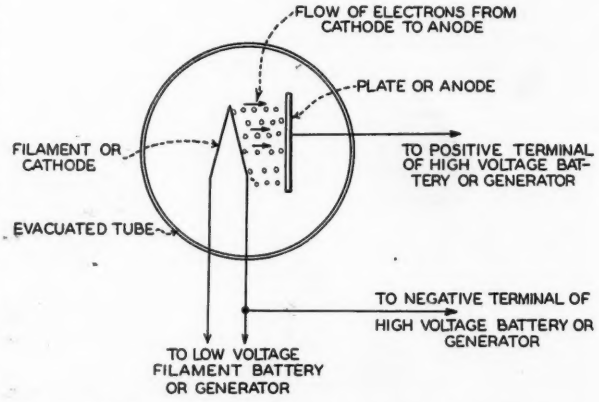

FLOW OF ELECTRONS FROM CATHODE TO ANODE
PLATE OR ANODE
FILAMENT OR CATHODE
TO POSITIVE TERMINAL OF HIGH VOLTAGE BATTERY OR GENERATOR
EVACUATED TUBE
TO NEGATIVE TERMINAL OF HIGH VOLTAGE BATTERY OR GENERATOR
TO LOW VOLTAGE FILAMENT BATTERY OR GENERATOR

Fig. 1. Fundamentally the vacuum tube consists of an incandescent filament and a metal plate mounted inside of an evacuated glass or metal envelope

"orbital" electrons in the atom also varies in a neutral atom. But it must be understood that the number of orbital electrons in itself does not alter the chemical nature of the atom. This means that it is perfectly possible to take an atom (in reality a group of atoms) and by rubbing, rub off one or more of the orbital electrons and the atom will then still remain an atom of the substance we started with. It will, however, no longer be a neutral atom and because some of the electrons have been removed, the combined negative charges of the remaining electrons will no longer balance the positive charge of the nucleus with the net result that the atom as a whole exhibits a positive charge. In this state, the atom will tend to attract any free electron that may be in the vicinity.

This is exactly what takes place when a stick of sealing wax or amber is rubbed with a piece of flannel. The wax becomes negatively charged and the flannel

[1] For a more complete explanation of the structure of matter and the nature of electricity the reader is referred to the author's book "Electricity—What It Is and How It Acts," Vols. I and II, but the brief description presented here is sufficient for an understanding of vacuum tube action.

positively charged. In the act of rubbing, the friction rubs off some of the electrons from the atoms composing the flannel and leaves them on the surface of the wax. Since the surface atoms or molecules (a molecule is a group of atoms) of the flannel are left deficient in electrons and the surface atoms of the wax with an excess, if the wax and the flannel are left together after being rubbed there will be a readjustment of electrons, the excess of the wax returning to the deficient atoms of the flannel.

With this "picture" of the atom in mind we can return to our consideration of the "free" electron. Most of the electrons in the universe exist as component parts of atoms as described but it is possible for an electron to exist in the free state apart from the atom, temporarily at least. Such free electrons

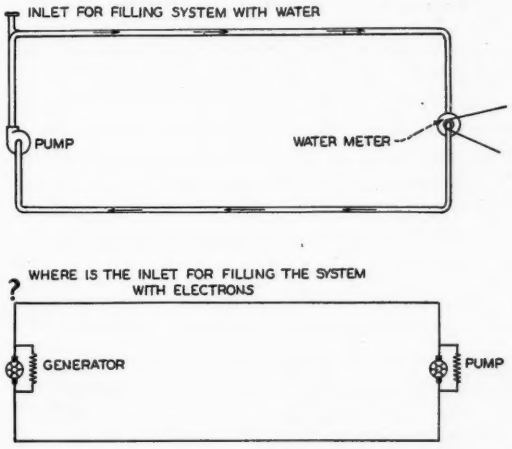


Fig. 2. Electricity is used to transmit energy from one place to another in the same way that water is used for the same purpose in a closed pipe circuit

exist everywhere to some extent, in gases, in liquids and in solids, but they are much more plentiful in some substances than in others.

Metals, for example, contain enormous quantities of them while substances such as glass and rubber contain only small amounts. It is the presence of these free electrons in substances that enable us to account for the conduction of electricity. The more free electrons a substance contains, the better conductor of electricity it is. Because of the enormous numbers of free electrons in metals, metals are good conductors of electricity. Substances such as glass, rubber, porcelain, mica, etc., on the other hand with comparatively small numbers of free electrons are poor conductors of electricity—good insulators.

These free electrons are in constant motion, bouncing back and forth, colliding with each other and the atoms in the most random fashion. This motion is due to the natural agitation of the atoms and molecules of any substance at normal and high temperatures. The higher the temperature of a substance the higher the speeds and the more violent the motion of the atoms and electrons, in fact, that is what "temperature" means.[2] The motion of the electrons is random. If, however, by some means we can control this random motion and make all the electrons move in one general direction we have what we call an electric current. Such a means of controlling or directing the electron motion is provided by an electric generator or battery.

Now we can understand better the analogy between the hydraulic transmission system and the electric system presented in a foregoing paragraph. The electricity needed for effecting the transmission of energy is contained in the metallic conductors forming the circuit in the form of these free electrons. By properly supporting these conductors on materials not having many free electrons, a path is provided over which these electrons can be directed, just as pipes provide a path for the flow of water. It is fortunate that air contains so few free electrons for otherwise it would be very difficult to prevent the free electrons in a conductor from flowing out where we do not want them.

Having such an electric "circuit," the question may be asked, "How are these electrons forced through the conductor? How are they set in motion?" We have said that this may be accomplished by a generator, but in what manner? In the case of the hydraulic system the pump piston traps a certain amount of water in an enclosed space (the pump cylinder), then, by forcing this piston down (decreasing the volume) the entrapped water is forced into the discharge line. At the same time the water on the suction side is forced into the space behind the piston. Thus a circulation is established.

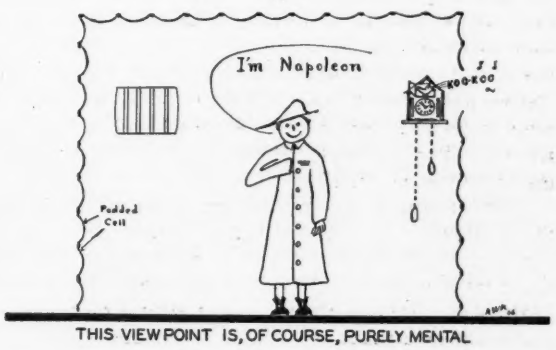
The action in the electrical system is similar. The generator, as was indicated, may be considered in the nature of a pump. The piston, in this case, is not a tangible thing but an electric field. Now it can be shown that when an electron is placed in an electric field, its own field[3] reacts with the field in which it is placed and it will be drawn toward the positive pole of that field. This is merely another way of saying that an electron is attracted by a positive charge.

Fundamentally, an electric generator consists of an arrangement whereby a moving magnetic field is

[2] When we say that free electrons exist in a substance we must qualify the statement by a more complete explanation of just what is to be understood by the term free electron. The term mobile electron probably would be more correct. In the close packing and random motion of the atoms of a metal, an outer electron of one atom is often brought within the influence of a neighboring atom. If such an atom is held rather loosely or if the attractive force of the neighboring atom is great enough, the electron will leave the first atom and go to the second. While this transition is in progress, the electron is more or less free to be acted upon by other forces and so is called a "free" electron. The result of this continual interchange brought about by the incessant vibration of the atoms, is a vast number of free electrons in the metal, moving in all directions at high speeds. If an electromotive force be applied to the metal the direction of motion will no longer be completely random for the electrons will be given a drift velocity in the direction of the positive terminal. This flow of electrons constitutes the electric current.

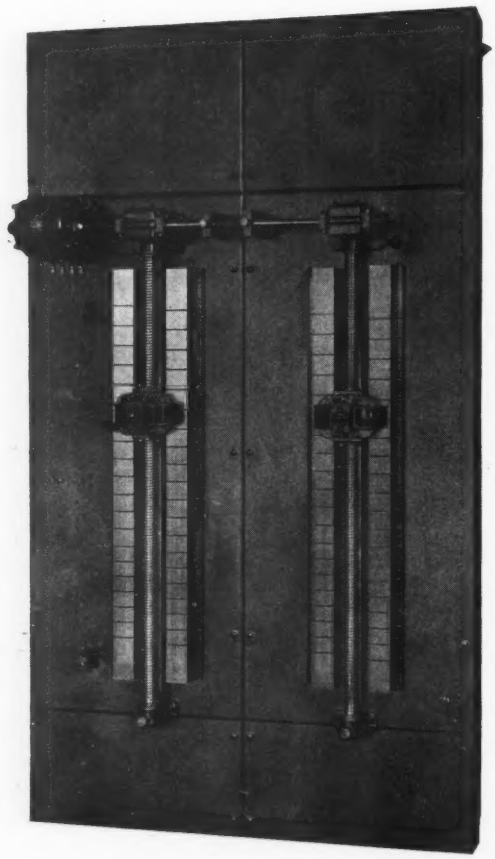
[3] Having an electric charge, every electron is of course surrounded by an electric field of force.

(Continued on p. 119)



THIS VIEW POINT IS, OF COURSE, PURELY MENTAL

FIELD RHEOSTATS



By C. A. JAGGER
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THE FIELD RHEOSTAT is one of those devices in the power plant which we take for granted and do not give much consideration. Compact, reliable, it does its work well and if properly installed will function for years without attention. Yet, the field rheostat is an important device and in recent years has reached a high state of development. ¶ In this article Mr. Jagger, who has spent a lifetime designing these devices, describes the various types available today and discusses the factors underlying their use and application.

THE CONSTRUCTION OF ELECTRICAL apparatus and the applications of it in almost infinite variety find their expression in many lines. Advancement in the art recognizes that many of the materials employed in earlier construction are still retained in modern apparatus, the difference being that in present day construction these materials have found their place and proportions to serve their greatest usefulness. Probably in no branch of the electrical industry has there been more rapid progress in eliminating methods which experience have proved deficient than in generator and motor control.

A field rheostat is a device to regulate the amount of current in a field circuit—either the current induced from a separate source of excitation or that within the generating power of the field itself. In order to regulate the field current the rheostat must include a resistance element or combination of resistance elements, which will reduce the amount of current in somewhat the same manner as a valve regulates the flow of liquid. Such a rheostat being connected within an energy circuit must dissipate the energy which it absorbs. This is done in the form of heat so that one of the first considerations is to deal with the best method of dissipating this heat without injury to the device itself or adjacent surroundings.

The subject of field rheostat control of direct and alternating current generators offers an opportunity to follow the progress that has been made in the construction and application of the various devices which effect this control.

The earliest field rheostats were extremely crude and unreliable. The first types were of moderate size and included iron wire as a resistor element. This wire was wound in a number of coil springs which were strung between two wooden bases. These in turn were definitely spaced by supporting rods at the corners. On one of the bases there were mounted copper or brass contacts arranged in a circle. The switch arm including a metal contact clip or finger was pivoted in the center. When turning the arm in either direction the finger would engage the contacts. The resistor coils in regular order were conected to the metal contacts by studs extending through to the back of the base and the main field leads were brought to two terminal posts also attached to the wooden element.

It can readily be seen that while fair ventilation could be obtained for the resistors to carry off the heat the possibility of over-heating meant that the bases

NOTE—One of the largest motor-operated switches for field rheostats made is shown in the illustration at the head of this article. It has a capacity of 1200 amp.

would be destroyed, possibly accompanied by a general conflagration.

The method of testing these earlier types of rheostats was very limited. The usual practice was to connect an incandescent lamp in series and if by passing the switch arm over the complete range of contact buttons, the lamp did not go out it was assumed that the rheostat was not open circuited and the construction was considered satisfactory. Little thought was given to the ohmic value of individual steps or the ability of the insulation to withstand a higher potential to ground.

Modern field rheostats while performing similar functions are constructed along very different lines and must meet exacting requirements in the regulation of motor speeds and generator voltages.

Factors Involved in Construction

The three principal points to consider in the general construction are resistor material, insulation, and switching mechanism. Considering the first named, it is evident that the best results will be obtained from a material which has a low temperature coefficient, thereby having a constant resistance at various temperatures. This material must also be as nearly noncorrodible as possible in order not to be affected by heating and cooling or atmospheric conditions. It is not the usual practice to design continuous duty field rheostats to exceed a temperature rise of 250 deg. C. so that under these conditions properly selected resistor materials should last indefinitely.

In order to minimize the amount of auxiliary apparatus field rheostats usually depend upon natural draft for ventilation. For large installations the size of the rheostat could be reduced by forced ventilation but little is saved on the initial investment, and the general work of maintenance is increased. There are also disadvantages to be met with in considering water cooled resistances, in that the electrolytic action especially with direct current shortens the life of the resistance elements to a marked degree. It is probably well that in the matter of field rheostats these methods of cooling need not be considered, as the largest field rheostats while often controlling large outputs of energy are not in themselves of abnormal dimensions.

The insulating material in field rheostats must be given careful consideration as weakness in this respect may cause a burn-out of the resistors resulting in a complete failure of the control. Rheostats for 600 volts or less when new should be able to withstand a high potential test between live parts and ground of at least double normal working voltage plus one thousand volts, for one minute.

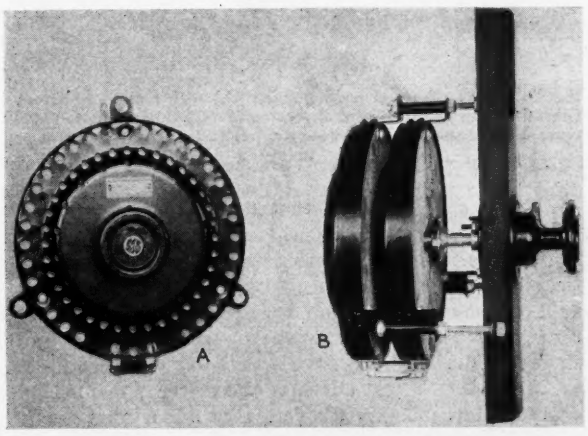


Fig. 1. Plate-type rheostats with resistor units imbedded in fireproof cement. (A) Mounted on front of control panel; (B) on back of panel. The two shown are 12 inches in diameter

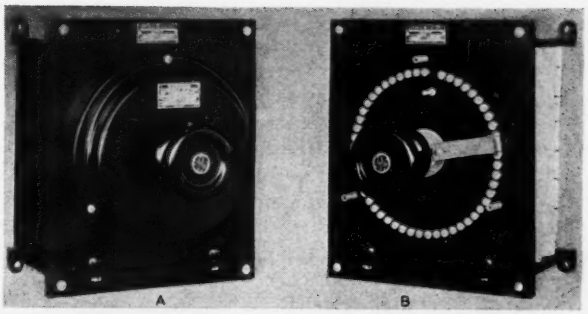


Fig. 2. Manually-operated box-type rheostats, for wall or bench mounting, having tube-type resistor units. (A) Rheostat complete with covers; (B) Rheostat with covers removed

There are a number of molded insulating compounds of unusual mechanical strength, which have in many instances replaced slate, marble and other natural products. These compounds are used largely for barriers and bases on which current carrying parts are mounted. The materials having organic ingredients can be molded into a great variety of forms but will not withstand as high temperatures as those of a ceramic nature. Mica still holds its own in the matter of offering the best moisture-proof insulation for the highest temperatures and in many types of rheostats mica is used for direct insulation between the resistor unit and the supporting framework.

The construction of dial switches on field rheostats presents a variety of combinations to meet the demands of different currents, from the very small to those employed in the excitation of the largest separately excited alternating current generators.

For currents up to 25 amp. an ordinary finger contact brush, depending on the spring quality of the metal only, is sometimes used. This type is most easily deranged and would hardly be considered for large currents.

For currents up to 350 amp. it is practical to use in the switch arms self-aligning solid metal contact brushes with the surfaces evenly faced and held by springs against the contact segments. Above this rating experience shows that a laminated brush is more satisfactory. As the laminations spread under pressure a more uniform contact is obtained.

Conductivity between the brushes and the stationary dial contacts depends directly upon the area of the parts in contact and the pressure. It is evident that abnormal pressure will mean excessive wear, thereby eventually causing reduced contact and frequent renewals. With the proper balance between pressure and area the parts can be kept within reasonable dimensions and their life greatly extended. The temperature at the point of contact should be limited to approximately 25 deg. C. rise, thereby reducing the rate of oxidation to a minimum.

In determining the proper field rheostat for a given service there are several points to be considered. In the

first place a field rheostat is not designed to withstand full line voltage; in other words, it has a maximum current rating limited by the resistance of the field with which it is connected in series. If for illustration a shunt wound generator is separately excited from 125 v. and the resistance of the field 12.5 ohms, the maximum field current would be 10 amp. With a rise in the exciting voltage, the field current would proportionately increase. Under normal conditions a rheostat of 12.5 ohms in series with the field, making a total of 25 ohms, would reduce the current to 5 amp. and lower the armature voltage accordingly. The extent to which the voltage would be lowered depends on the design of the machine as determined by the field saturation curve.

A rheostat for this service therefore would be tapered from its first to last step from 10 to 5 amp. and the ohms per step so proportioned as to approximate equal watts per step. If this same rheostat were used with a generator separately excited from 250 v. and having a field resistance of 25 ohms, the first step of the rheostat would still have sufficient capacity but after turning in the 12.5 ohms, 6.7 amp. would flow instead of 5, which might burn out the rheostat. This shows the care which must be exercised if a rheostat designed for one voltage is used on a higher voltage circuit. If the maximum capacity were satisfactory and a 250-v. rheostat used on 125-v. source, the only result would be that the rheostat would have more capacity than necessary after the first step was passed.

In the case of some separately excited direct current generators, it is desirable to have a range in armature

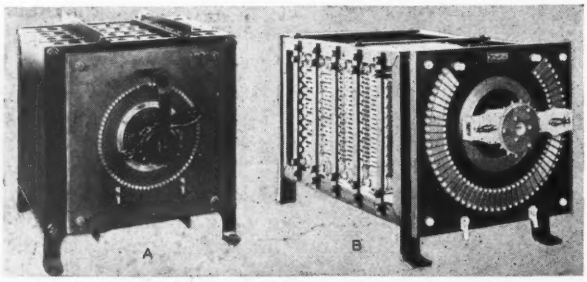


Fig. 3. Box-type rheostats, too large for mounting on panel, are sprocket-operated. Rheostat (A) has tube-type resistor units (B) cast-iron grid resistor units

voltage from zero to maximum. This is accomplished by providing the field rheostat with potentiometer connections. One terminal from the field is connected to one end of the resistance and the other to the center post of the switch arm. The excitation voltage is brought to both ends of the resistance. With the switch arm in one extreme position maximum potential is placed across the field while in the other extreme the field is short circuited.

Rheostats for separately excited alternator fields often give sufficient regulation if the resistance is equal to the generator field, however, it is a standard practice to include somewhat more resistance, as the machine may be operated through a considerable range of power factor load.

Field rheostats for self-excited direct current generators having resistance equal to the field will usually give sufficient regulation, but generally a reduction of 50 per cent of the normal voltage is desired. This results in interrupting much less current when the field switch is opened. It is always best, if possible, to consider the actual field saturation curve of the generator especially if definite voltage regulation is required. To obtain these results it may be necessary to design the rheostat with varied ohms per step and with watt capacities calculated to suit.

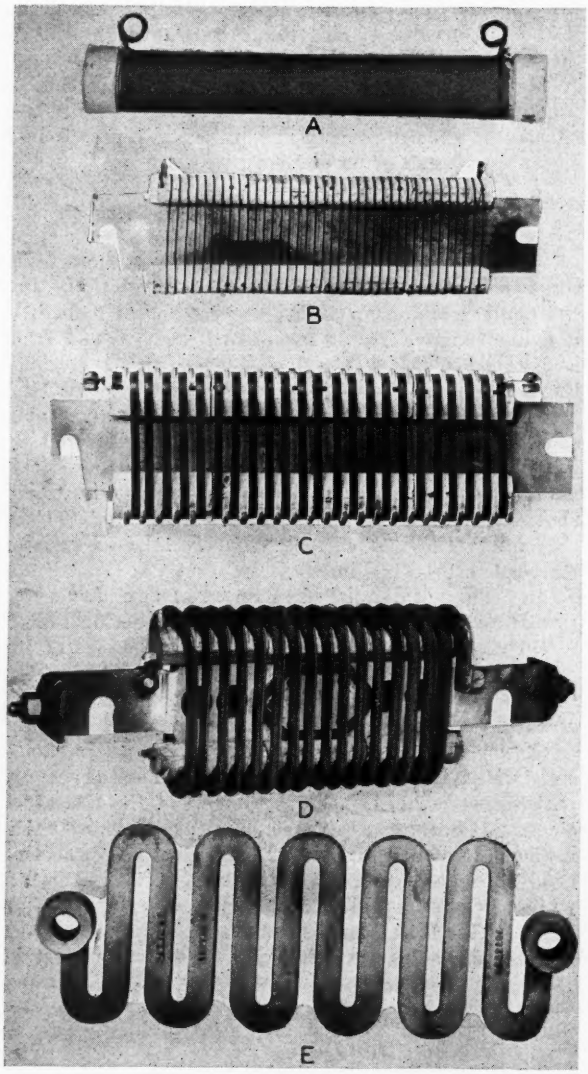


Fig. 4. Various forms of resistor units: (A) with cement or vitreous enamel covering; (B) open, wire-wound; (C) open, ribbon-wound type; (D) edgewise, ribbon-wound type; (E) cast-iron grid resistor unit

The design of field rheostats for direct current motors follows along the same line. A rheostat connected in series with a series wound motor will reduce the speed while one connected in series with the shunt field of a shunt or compound wound motor will increase the speed. To obtain exact speeds according to definite steps on the rheostat it is necessary to have a calculated or, preferably, a test curve of the motor, showing field current plotted against revolutions per minute.

It is the usual practice in choosing field rheostats to base the maximum ampere capacity on the cold resistance of the field as this represents the lowest field

ohms and highest current. The temperature coefficient of the copper field coils will reduce the amperes, but the rheostat will reach its maximum temperature in much less time.

Most field rheostats installed are manually operated. This is because the average rheostat is small, convenient to mount, easy to operate and low in cost.

Types Available

Small and medium size generators and motors usually employ field rheostats of the plate type. These are readily mounted on the front or back of a control panel. They include one or more plates, usually of the disc type from 6 to 15 in. in diameter. Those of the same size are mounted on common tie rods and joined mechanically for operation by a single handwheel. Electrically they can be connected in series, multiple or series-multiple. The resistor units in each plate are made of alloy wire formed in a zig-zag pattern or wound in small open coils. These are connected in series and attached to the contacts on the plate. The plate may be made of fireproof compound or metal. If compound the units are embedded in fireproof cement but if metal they are surrounded by vitreous enamel which also forms the necessary insulation.

The plate type rheostat has its limitations, however, in that for a given current the total resistance which can be included is governed by the dimensions of the plate. The controlling factor is the number of watts which can be dissipated from the surface of the plate. If the temperature rise is not to exceed 200 deg. C. the rating must be limited to approximately 3 watts per square inch.

Manually operated field rheostats which are too large to mount conveniently on the panel are usually of the box type, either sprocket or gear driven, with the operating mechanism on the panel.

For medium ampere capacities there is a variety of resistor units available. The simplest forms include ceramic tubes wire wound and covered with either vitreous enamel or heat-resisting cement. The vitreous enameled units are usually not more than one foot long and one inch in diameter, while the cement covered may be twice this size. They are connected in series or series-multiple so that almost any requirement can be met within practical limits by simply adding units and increasing the dimensions of the supporting framework.

Cast Iron for Heavy Currents

Other forms of units in this ampere range include open construction where ceramic blocks or cleats are attached to metal supports over which medium size resistance wire or ribbon is wound. Sometimes the ribbon is wound edgewise. The latter arrangement gives increased capacity as more radiating surface is available in a given space. Resistance ribbon formed into loops and supported at the ends, or tie rods through the center is also used in convenient sizes.

Field rheostats required to carry much above 100 amp. usually employ cast iron grids as the resistor element. These grids are made in a large number of capacities. The maximum continuous rating for a single unit is approximately 150 amp. The design is such that the resistance is limited only by the size of

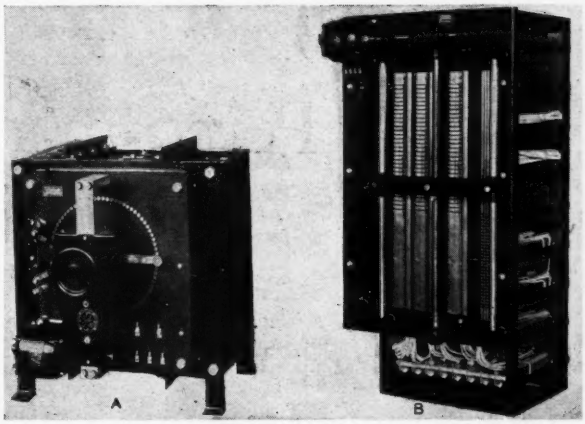


Fig. 5. Motor-operated rheostats are used for distant location with control switch on panel. Rheostat (A) has tube-type resistor units; (B) a combination of cast-iron grids, open ribbon, and wire-wound resistor units

the cross section and the length. Castings are seldom made in extremely small sections, lest they become too fragile. The most popular ones have dimensions ranging from one-tenth to two-tenths of a square inch on cross section and are made in rectangular form and cast in zig-zag loops. The overall dimensions of the finished grid seldom exceed 6 in. wide by 18 in. long.

The use of grids avoids a larger number of lower capacity units of other forms in multiple. Separate wire connections between grids are not necessary as the end lugs are ground to a true even surface and the current is carried across with a minimum of contact resistance. Pressure between grids, in each tier, is provided by the clamping nuts on the ends of the supporting tie rods.

Even with cast grids, when several are run in multiple, it is sometimes necessary to parallel the lugs with metal bridges to avoid too high a concentration of current. Several units grouped together in a tier will have somewhat less watt capacity for a given temperature rise than a single unit in the open air. As with all types of resistor units this must be taken into consideration when designing the supporting framework so that adequate ventilation will be provided.

The steady advance in the size of separately excited alternating current generators has resulted in field currents in excess of 1000 amp. In such instances several cast grids are connected in multiple, but the number so connected is lessened as the field current is reduced to the minimum value.

Practically all field rheostats, except the plate type, have the resistor units connected to the dial switch with solid or flexible copper leads covered with flame proof insulation.

Many field rheostats of large and small capacities have dial switches which are motor operated for the convenience of having the rheostat in any desired location with the control device on the panel.

Most field rheostats where the field current exceeds 300 or 400 amp. are motor operated. The heavy contact of the dial switch is not easily overcome with any simple form of manual control. These rheostats are usually too large to install close to the control board and in some instances the only available space is in the generator room.

Engine Performance *and* Jacket Water Temperature

Tests at the Bureau of Standards (reported in N.A.C.A. Tech. Note 476) show the effects on engine performance of change in jacket-water outlet temperature

By E. A. Garlock and Greer Ellis

BECAUSE OF THE INTEREST in this subject a brief experimental program has been conducted in the Altitude Laboratory to determine the effects of change of jacket-coolant temperature at altitudes of 10,000 and 20,000 ft. as well as at sea level. The only coolant used was water and the range of available temperatures was therefore limited to that between the coldest obtainable from the city water mains and a maximum of 100 deg. F. The tests were made at but one speed and one compression ratio.

The engine used was a Curtiss D-12 twelve-cylinder, V-type with a compression ratio of 5.3:1, a displacement of 1,160 cu. in., and with a sea level rating of 435 br.hp. at 2,300 r.p.m. All test runs were made at an engine speed of 2,000 r.p.m. at which speed the normal sea-level power was 401 br.hp. at 77 deg. C. jacket temperature. The carburetor intake air was held at 15 deg. C., being first dehumidified by cooling to below —40 deg. F. By means of an external oil reservoir the oil inlet temperature was held constant at 60 deg. C.

Fuel consisted of a mixture of one-third benzol and two-thirds domestic aviation gasoline. The oil used was Liberty Aero, grade Three, possessing a Saybolt Universal viscosity of 697 sec. at 130 deg. F. and 98 sec. at 210 deg. F. All results are based on maximum power values obtained from mixture ratio runs.

For the purposes of this report, indicated horsepower is defined as the sum of the measured brake horsepower and the friction horsepower, the latter being the power required to drive the engine when motoring with the dynamometer. Volumetric efficiency is defined as the ratio of the volume of air received per cycle, measured at the temperature and pressure existing at the carburetor entrance to the piston displacement. Because less heat was absorbed by the jacket water in the friction runs, lower jacket temperatures were possible than when operating under power.

Referring to Fig. 1, the friction horsepower at all three altitudes decreases approximately linearly with increasing jacket temperature. At an altitude of 20,000 ft. the friction horsepower decreases 0.52 per cent for each degree increase in jacket-water temperature. At an altitude of 10,000 ft. the decrease is 0.50 per cent for each degree increase in jacket-water temperature and at sea level 0.39 per cent. Frank[1] found that the friction of a Curtiss Conqueror engine operating at sea level was approximately linearly variant

[1] Frank, Gerhardt W.: High-Temperature Liquid-Cooling, S.A.E. Journal. Vol. 25, No. 4, October, 1929, pp. 329-343.

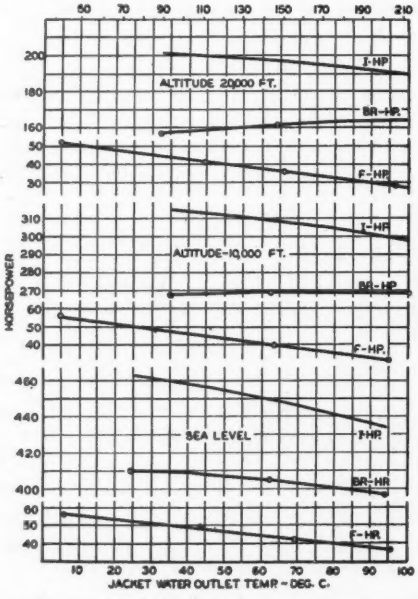


Fig. 1. Variation of power with water temperature and altitude

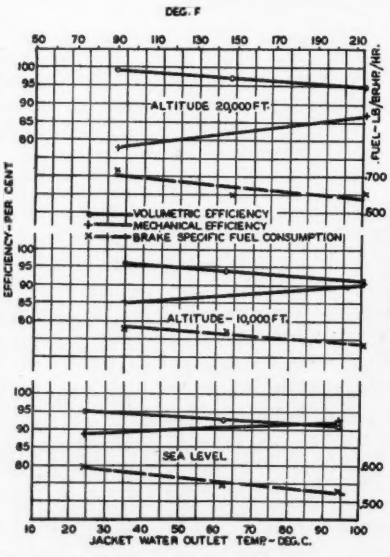


Fig. 2. Variation of volumetric, mechanical and specific fuel consumption

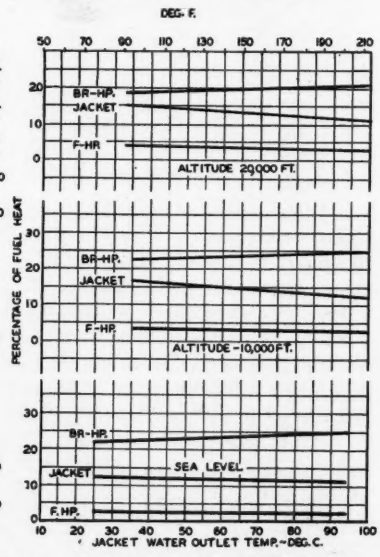


Fig. 3. Variation in the distribution of heat balance useful work and jacket water

with jacket-coolant outlet temperature, the average decrease being 0.33 per cent for each degree increase in temperature.

This change in friction horsepower is primarily due to change in the viscosity of the oil. Oils vary widely in their viscosity-temperature relation. Accordingly other oils would affect friction and consequently brake horsepower differently. It seems probable that an oil with a different viscosity-temperature coefficient would give a friction curve of different slope, while an oil of similar viscosity-temperature coefficient but of different Saybolt viscosity at a given temperature would shift the curve parallel to itself.

Brake power decreases with increasing jacket-water temperature at sea level, is nearly constant at 10,000 and increases at 20,000 ft. The indicated horsepower at all altitudes decreases with increasing jacket water outlet temperature, the percentage decrease for an increase in jacket water temperature from 35 to 95 deg. C. being 5.7 per cent at sea level, 4.5 per cent at 10,000 ft. and 5.5 per cent at 20,000 ft.

Volumetric Efficiency Decreased

Change of volumetric efficiency and mechanical efficiency with jacket-water temperature at sea level and at altitudes of 10,000 and 20,000 ft. is shown in Fig. 2. Volumetric efficiency decreases with increasing jacket-water temperature because the increased warming in the jacketed intake manifolds and cylinders decreases the charge weight inducted. Increase in mechanical efficiency results from the more rapid decrease of friction than of indicated power with increasing jacket temperature. The percentage change in brake horsepower is approximately equal to the net change in the volumetric and mechanical efficiencies.

This is in accord with Ricardo's view that the change in power is due to the variation in volumetric efficiency and friction, and only negligibly to change in heat loss from the ignited charge to the jacket with variation in jacket temperature. Referring to Fig. 2, at sea level, the increase in mechanical efficiency is 1.3 per cent for the range of jacket-coolant temperature 69.5 deg. C. to 100 deg. C., whereas Frank with a Curtiss Conqueror engine noted an increase of only 0.5 per cent.

The tendency at all altitudes is for the brake specific fuel consumption to decrease with increasing jacket-water temperature. This tendency is due largely to the increase in mechanical efficiency with increasing jacket-water temperature and to better vaporization of the fuel due to the warming up of the intake manifolds.

Tests by others using a Curtiss Conqueror engine varying the jacket-coolant temperature from 86 to 149 deg. C. showed that the brake specific fuel consumption decreased gradually until the temperature reached 121 deg. C. and then increased. For a given engine the temperature at which this reversal occurred would doubtless be a function of the oil characteristics.

At sea level the falling off in brake horsepower with increasing jacket temperature partly offsets the advantage gained due to the decrease in specific fuel consumption. For the range covered, the decrease in brake specific fuel consumption is 13.7 per cent, whereas the decrease in brake power is only 3.4 per cent. In the case of aircraft engines this decrease in specific fuel consumption may be a great advantage and more than offset the disadvantage of the decrease in power output.

In analyzing the distribution of the available heat in the fuel and in computing thermal efficiency, a value of 19,600 B.t.u. per lb. was assumed. Since the exhaust gases were cooled by injecting water into them the higher heating value of the fuel has been chosen. In Fig. 3 the percentage of fuel heat appearing as useful work is seen to increase linearly with increasing jacket-water temperature at all altitudes. The percentage of fuel heat carried away by the jacket water decreases with increasing temperature at all altitudes because of increasing radiation and convection from the engine.

Friction horsepower has been plotted as percentage of heat in the fuel. While a part of the friction no doubt appears as heat in the jacket water, no difference was detected in intake and outlet jacket-water temperatures when taking friction power readings. The amount of water circulated through the jacket was about 200 kilograms per minute (about 52 g.p.m.) and the temperature readings are probably accurate to within plus or minus 0.5 deg. C. It is evident that the greater part of the friction is accounted for as heat lost in radiation and convection, pumping losses and power required to drive the gears, pumps and accessories.

Electron Tubes

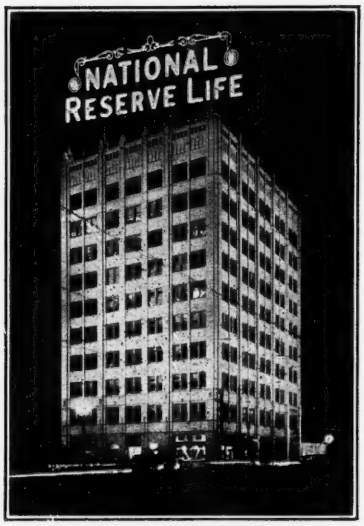
(Continued from p. 113)

made to cut groups of conductors. Now it can also be shown that a moving magnetic field creates an electric field and it is this electric field which sets the electrons in the conductor in motion. When the generator is set in motion the electric field produced between the terminals of the machine acts upon all the electrons in the circuit and they all start to move at once in the direction of the positive terminal. As long as the generator is kept in motion, the free electrons in the circuit will continue to circulate.[4]

To those who are familiar with the laws of electric currents the statement that the electrons move toward the positive terminal may be puzzling in view of the fact that in electrical circuits the current is said to be the flow from positive to negative—just opposite to the action described here. The reason for this contradiction is that the accepted view considering the current to flow from the positive to the negative terminals is wrong. It is due to the fact that the pioneer electrical experimenters having no knowledge of the electron and therefore no real understanding of the nature of an electric current, arbitrarily assumed the direction of current to be from positive to negative. Unfortunately, as now disclosed by the electron theory, they chose wrongly but the convention persists to this day. In view of present knowledge this convention should be abandoned since it is extremely confusing when dealing with electron tube circuits.

[4] The number of electrons involved in the conduction of current is enormous, though it may be found by simple calculation. One ampere of electricity, for example, is defined as the flow of one coulomb of electricity per second past a given point in a conductor. Since the charge on an electron is 1.591×10^{-19} coulomb, a flow of one ampere requires that 6.3×10^{18} electrons move past a given point in the conductor second.

Air Conditioning Office Buildings



Topeka, Kansas, has first large office building west of the Mississippi to be completely air conditioned

IN 1925 the National Reserve Life Insurance Co. erected its 10-story office building at Topeka, Kan. Last year complete air conditioning of the entire building was undertaken. The installation is remarkable in a number of ways. Direct-expansion Freon refrigeration is used throughout with the condenser and receiver located on the roof, 130 ft. above the compressors in the basement. The building is divided into 38 zones with separate controls used for regulating the conditions in each zone in accordance with the number of persons inside and the temperature, sunlight and humidity conditions outside.

A total of 131 t. of refrigeration is installed, supplied by three Frick enclosed-type Freon compressors. Two of these have cylinders of 8¾ in. bore by 6 in. stroke, while the third unit is a 7¾ by 5 in. unit. Each of the larger machines is driven by a 50 hp. G.E. motor, the smaller compressor being operated at either of two speeds by a 40-20 hp. G.E. motor. This grouping of the horsepowers available offers the equivalent of eight machines; 20, 40, 50, 70, 90, 100, 120, and 140 hp. and a Minneapolis-Honeywell multiple-step controller selects the right combination of machine capacities to match the load on the cooling system. Compressors are mounted on heavy foundations isolated with cork and sand.

The main discharge line is a 6-in. copper pipe, running vertically through a 3 by 4 ft. shaft to the roof, where it enters the horizontal shell-and-tube condenser. The total run of this 6-inch line is no less than 160 ft. probably a record for this class of service. The main riser is secured by hangers and is supported at the top by a cable which passes over a wheel to a 350-lb. counterweight. The multipass condenser, 30 in. in diam. by 15 ft. long is so placed under the cooling tower that the water runs over the outer surface of the shell to add more than 11 per cent to the effective surface. The receiver is welded underneath the condenser.

After leaving the receiver, the liquid Freon passes through a new type of drier charged with alumina gel, and a Cuno filter. This filter comprises a series of thin steel discs, spaced 0.008 in. apart; by means of a handle outside the filter case, the discs can be turned past a set of fine plates extending into the spaces between them, thus cleaning the filter. The liquid next

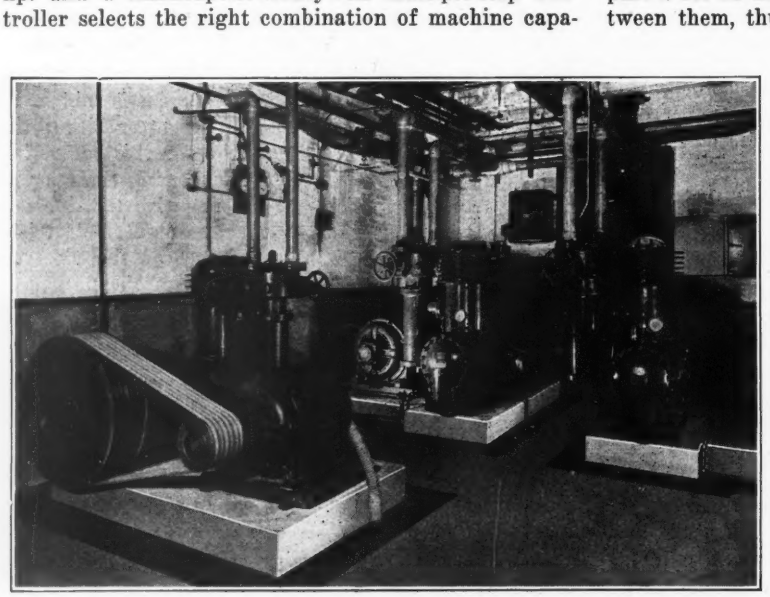


Fig. 1. The machine room showing the three Frick enclosed-type Freon Compressors which supply 131 t. of refrigeration

Fig. 2. Arrangement of ducts is such as to give good distribution of conditioned air to all rooms in the building

drains downward to the direct-expansion Trane air conditioning units on each floor. The ground floor has a separate blower unit for each of the stores or rooms; on each of the other floors of the building, a single unit supplies conditioned air to the various rooms, through ducts.

These individual blower units on the upper floors are located in the janitor's closet, adjacent to the pipe well. The liquid feed to each unit passes first through a Frick electric control valve, which provides positive opening or closing of the line, and then through a thermostatic expansion valve. The control of the electric valves is part of the Minneapolis-Honeywell system which automatically governs the entire plant.

Unique Duct System

On the conditioning unit itself there is provided an economizer control for the fresh air supply, this control to respond to the temperature of the outside air so as to open the fresh air dampers when the outside temperature is such that this fresh air is suitable for cooling purposes. A humidity controller is also used to prevent the opening of the fresh air damper, or to close it so that only 1000 cu. ft. of fresh air is admitted at times of excessively high humidity outside, such as during a rain. These blower units, as used on most of the floors, include 8 Trane coils, each of six rows, with a face area of 18 in. by 48 in., and have a Buffalo Forge blower driven by a 2-hp. G.E. motor. Each unit provides 17 t. of cooling capacity.

The blowers operate continuously whether the refrigerant is turned off or on. The air leaving each of the rooms (on the floors above the first) returns to the hallway through a grille in the bottom of the door, and from the hallway is recirculated through the ducts. No special fresh air inlets had to be provided on the first floor, this being taken care of by the opening of doors and windows. A portion of the air, due to the pressure inside the building, escapes through the window cracks. All the windows in the building are equipped with white wooden venetian blinds.

The duct system in this building is quite unique. Three trunk lines come off the unit—one doubling back of the unit to supply the rooms in that direction and the other branch goes straight ahead, catching the rooms in the front of the unit on the same side of the hall the unit is located on; while the third branch crosses the hall and spreads both ways to supply that side of the building. An archway was built in to conceal the duct as it crossed the hall. All ducts were metal lathed and plastered to look like beams.

The system is guaranteed to maintain inside conditions of 85 deg. dry bulb and 71 deg. wet bulb, when the outside conditions are 100 deg. dry bulb and 77 deg. wet bulb. Stated in other words, the relative humidity inside the building is maintained at about 50 per cent and the temperature is from 10 to 15 deg. below that on the street.

The system operated satisfactorily through the past season, and proved to have ample cooling capacity. During the hottest days the head pressure never went above 130 lb. gauge, in spite of 108 to 110 deg. weather with very high relative humidity.

Repairing Pitted Turbine Runners

By W. E. Warner

Runners of hydraulic turbines often get pitted and grooved due to the action of the high velocity water. For filling in these pits and grooves electric arc welding is entirely satisfactory. Oxy-acetylene welding has not been found entirely satisfactory owing to the difficulty in getting a uniform heat and preventing shrinkage cracks. Runners can be welded without removing from their position, provided the welder can reach the damaged parts. If the parts cannot be reached, dismantling will be necessary. The parts to be welded should first be cleaned by a wire brush down to the base metal. A very satisfactory filling material has been found to be a manganese hard steel welding rod. This has a high resistance to the erosive action of the water.

Whatever filling rod is used it must have a high resistance to pitting and grooving. An experienced welder will have no difficulty in getting a sound weld, provided the filling metal selected suits the base metal.

The weld should afterwards be ground down to the level of the rest of the metal of the runners so that it has a perfectly smooth surface.

A WPA Allotment of $749,994 has been made for the construction of a concrete arch dam 250 ft. high in Sabino Canyon in the Coronado National Forest. This dam will provide a mountain lake for boating, fishing, bathing and will also control floods. The project was sponsored by the Board of Supervisors of Pima County, and the Forest Service issued a special use permit.

Systems for Returning Condensate to Boilers

Features Governing Choice of System to Be Installed

BY RETURNING condensate to the boiler as quickly as possible after it has been formed instead of allowing it to go to the sewer, a plant may save on the cost of the water and its treatment and the cost of fuel necessary to raise the temperature of the feedwater from that of the cold supply to that of the returned condensate. It must be recognized, however, that all condensate is not suitable for boiler feeding purposes as it may be contaminated with oil or other foreign impurities resulting from industrial uses, or the point of condensation may be so distant that the cost of returning it would be economically prohibitive.

Due to the savings possible, much study has been given to the development of systems and equipment whereby the condensate and its heat may be reclaimed. Just which system is most desirable for a particular plant depends on many conditions, the most important of which have been summarized and tabulated by Russell T. Gray, Inc. This tabulation, together with the diagram presented herewith, should prove helpful to those encountered with the problem of returning condensate to the boiler.

The simplest system considered here is the gravity return line and because of its extreme simplicity it should be given first consideration. Its limitations, however, confine its application to a rather narrow field. By this arrangement steam coming from the boiler, enters the heat exchange unit where it is condensed and this condensate flows by gravity back to the boiler. The heat exchange units must be at a sufficient elevation above the boiler to insure rapid return of the condensate and for the same reason the return pipe must be of ample size and horizontal runs must have a decided pitch toward the boiler. The use of separating traps in this system, while not always essential, perform the function of keeping air and steam from entering the return pipe, thus preventing air binding and waste of heat from the return line.

Where the gravity return system is sluggish due to a lack of sufficient head between the heat exchange unit and the boiler, the return trap is frequently used to solve the problem. Here the trap is located at least 6 ft. above the water line in the boiler.

When the trap receptacle is filled the trap mechanism causes steam at boiler pressure to enter the trap and force the condensate out of the trap on its way to the boiler feed line, the emptied receptacle is then closed against steam from the boiler, what steam remains after each dump either condenses due to radiation and the cooling effect of the incoming condensate, or passes with what noncondensible gases are present through a vent to atmosphere.

When the return condensate is at an elevation below that of the boiler, resort may be made to one or more of four common systems of returning condensate. The lift trap functions in precisely the same way as the return trap except that delivery is to a return trap instead of to the boiler. This is possible because 1 lb. of steam pressure on top of the condensate in the trap receptacle is sufficient to raise the water approximately 2 ft.; common practice, however, is to provide at least 1 lb. steam pressure per 1 ft. elevation of the water to give sufficient flow and take care of friction.

When a boiler feed pump is used to return the condensate, the returns all come back to a receiver from which the feed pump draws its supply. In many cases a receiver and feedwater heater are combined in one unit.

Many heat exchange units operate under low or even vacuum pressures and in such cases the condensate must be drawn off by a vacuum pump discharging to one of the other systems for return to the boiler.

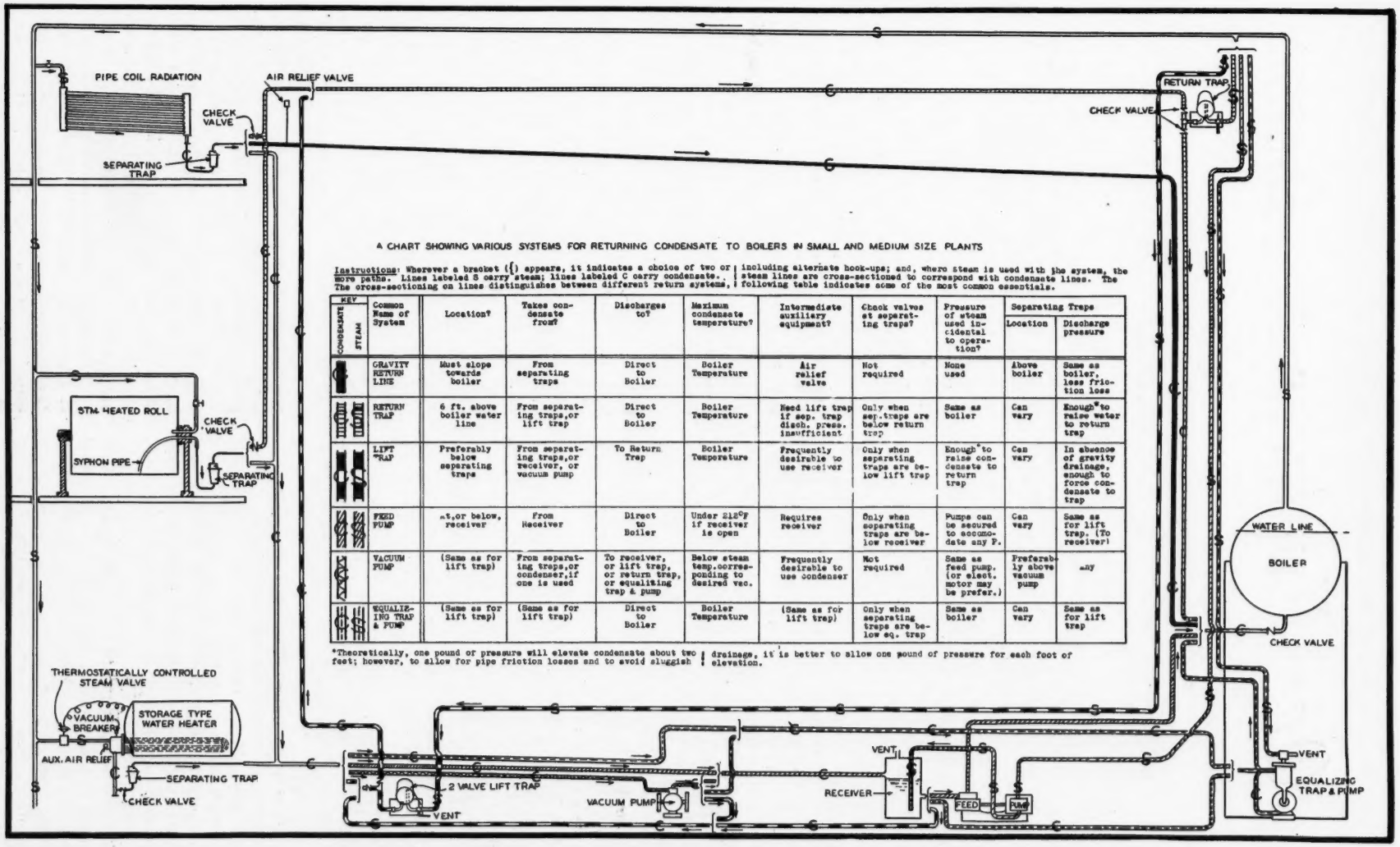
Combining the functions of a receiver and boiler feed pump in one unit, the equalizer trap and pump system consists of a closed receptacle into which condensate drains from the various heat exchange units. A float within the the receptacle controls the starting and stopping of a motor driven centrifugal boiler feed pump as the condensate accumulates and is drawn out of the receiver. The float also operates vent and equalizer valves, the former being held open to relieve the pressure within the tank during the filling operation and closed while the condensate is being drawn off, while the equalizer valve admits steam at boiler pressure during the time the condensate is being pumped to the boiler, thus reducing the head on the pump, and is kept closed while the condensate is filling the tank.

It will be noted in the tabulation that separating traps are specified for use in all systems. As stated above, their function is to prevent air and steam from entering the return pipe, thus they establish the points in the system where steam is held on one side and water is transferred to the other, they are quite essential where more than one unit is being drained by the system. By this means all steam consuming units are kept dry and therefore always have maximum capacity. By the use of separating traps faster circulation is secured and the return system capacity increased.

To secure the greatest advantage of condensate return systems, the water should be returned as quickly as possible and the piping insulated to reduce heat loss.

OUT OF EVERY 100 kw-hr. of electricity produced at the generating stations only about 83 kw-hr. reach the meters of public utility customers, according to data compiled by the Edison Electric Institute. In other words, 17 per cent of the electricity generated is "lost" somewhere between the power house and the ultimate consumer, or, putting it another way, every time a utility customer uses 100 kw-hr. of electricity, there must be generated at the power station about 120 kw-hr.

The power described in company records as "lost or unaccounted for" is not actually lost in the sense that it escapes from the transmission lines but is, of course, the energy loss which inevitably accompanies the transmission of power over any electrical system.



A CHART SHOWING VARIOUS SYSTEMS FOR RETURNING CONDENSATE TO BOILERS IN SMALL AND MEDIUM SIZE PLANTS

Instructions: Wherever a bracket ({) appears, it indicates a choice of two or more paths. Lines labeled S carry steam; lines labeled C carry condensate. The cross-sectioning on lines distinguishes between different return systems, including alternate hook-ups; and, where steam is used with the system, the steam lines are cross-sectioned to correspond with condensate lines. The following table indicates some of the most common essentials.

KEY: CONDENSATE / STEAM	Common Name of System	Location?	Takes condensate from?	Discharges to?	Maximum condensate temperature?	Intermediate auxiliary equipment?	Check valves at separating traps?	Pressure of steam used incidental to operation?	Separating Traps: Location	Separating Traps: Discharge pressure
	GRAVITY RETURN LINE	Must slope towards boiler	From separating traps	Direct to Boiler	Boiler Temperature	Air relief valve	Not required	None used	Above boiler	Same as boiler, less friction loss
	RETURN TRAP	6 ft. above boiler water line	From separating traps, or lift trap	Direct to Boiler	Boiler Temperature	Need lift trap if sep. trap disch. press. insufficient	Only when sep. traps are below return trap	Same as boiler	Can vary	Enough* to raise water to return trap
	LIFT TRAP	Preferably below separating traps	From separating traps, or receiver, or vacuum pump	To Return Trap	Boiler Temperature	Frequently desirable to use receiver	Only when separating traps are below lift trap	Enough* to raise condensate to return trap	Can vary	In absence of gravity drainage, enough to force condensate to trap
	FEED PUMP	...t, or below, receiver	From Receiver	Direct to Boiler	Under 212°F if receiver is open	Requires receiver	Only when separating traps are below receiver	Pumps can be secured to accommodate any P.	Can vary	Same as for lift trap. (To receiver)
	VACUUM PUMP	(Same as for lift trap)	From separating traps, or condenser, if one is used	To receiver, or lift trap, or return trap, or equalizing trap & pump	Below steam temp. corresponding to desired vac.	Frequently desirable to use condenser	Not required	Same as feed pump. (or elect. motor may be prefer.)	Preferably above vacuum pump	...ny
	EQUALIZING TRAP & PUMP	(Same as for lift trap)	(Same as for lift trap)	Direct to Boiler	Boiler Temperature	(Same as for lift trap)	Only when separating traps are below eq. trap	Same as boiler	Can vary	Same as for lift trap

*Theoretically, one pound of pressure will elevate condensate about two feet; however, to allow for pipe friction losses and to avoid sluggish drainage, it is better to allow one pound of pressure for each foot of elevation.

As One Engineer to Another—

Temperature, Heat and Pressures Come in for Discussion by G. F. and the Chief

By G. F. WETZEL

HAVING BEEN somewhat busier than usual, I had not seen my good friend, the Chief Engineer, for some time. So, as I was in his neighborhood I dropped in for another chat with him.

"Glad to see you, G. F.," he greeted me. "I suppose that you thought it was about time I got another batch of high grade education. But I haven't been waiting for you, I've been doing some brushing up on my own account, and so you see,—I know most of the answers already."

"That's just fine, Chief," I told him. "Maybe you can help me out. I was wondering what was the difference between heat and temperature, and also thinking of all the different ways of specifying pressures. Tell me,—how would you explain the difference between heat and temperature, or isn't there any difference, and if not, why not?"

"Well you see, G. F.,—temperature is——, well, you know what it is,—why ask me? And heat is what makes things get hot." He looked as if he would like to change the subject, knowing that he had been too hasty in claiming to know all the answers in advance. But I saw a chance to impress some facts on him, that was too good to miss.

"In other words, Chief," I answered, "You have made it very clear that temperature is merely the level at which the effect of heat becomes manifest, measured by arbitrary units called 'degrees', the Fahrenheit scale having 180 deg. between freezing point of water and its boiling point at atmospheric pressure, with zero located at 32 deg. below freezing, atmospheric boiling point at 212 deg. above zero, and absolute zero at 460 deg. below zero."

"Yes, that is just what I meant," the Chief said with a mischievous gleam in his eye, "And now I suppose you would like me to tell you what 'absolute zero' means."

"I know what you are going to tell me," I replied, —"That absolute zero is the absolute bottom of temperature below which there is and can be no lower temperature,—the point where all molecular motion ceases,—where all matter, solid, liquid, gaseous,—becomes inert solid matter. Also that absolute temperatures are given as the sum of the Fahrenheit degrees plus 460 deg.

"You took the words right out of my month, G. F. I was going to add that the reason we care anything about absolute temperature is—is—," he waited for me to interrupt him.

"Yes, Chief, you were saying that the reason we bother with absolute temperature is that the specific volumes of gases and vapors increase as the absolute temperatures at constant pressure,—absolute pressures of gases and low-pressure vapors increase as the absolute temperature at constant volume,—and specific weights change inversely as the absolute temperatures change."

"You certainly are a mind reader, G. F. I couldn't have said it better myself," the Chief added.

"Quit bluffing, Chief," I told him, "and if you don't want to admit how dumb you are on the subjects of today's lecture,—heat, temperature and pressures,—wait until I finish, and if you have not learned something new, then I'll admit that I am dumb.

"Heat is a form of energy that can become manifest at any temperature,—that flows or transfers from higher to lower temperatures,—that under certain conditions by the input of outside energy, can be made to flow from cooler to warmer temperatures—(refrigeration)—that can cause changes of state, for example,—evaporating water into vapor or steam, with no change of temperature,—that can be transformed into other kinds of energy such as electrical, mechanical, chemical, light, sound. Heat as energy has nothing to do with temperature, as it is perfectly possible to have heat exchanges at 100 deg. below zero or lower, as well as at 2000 deg. above zero or higher. To illustrate changes in the type of energy, let's follow through the generation and use of electricty. To start with, fuel is burned under a boiler,—a chemical change (combustion)—causing heat, this causing a change in state of water into steam (change in molecular and mechanical energy),—the steam going into a turbine and causing rotation of the rotor and generator armature or field as the case may be, mechanical energy changing to electrical energy in the generator. The electrical energy will operate motors (mechanical energy) will operate lights (light and heat energy), furnish the power for radio receivers (sound, light, and heat energy), operate electrical heating devices (heat energy again). So you can see that changes in energy types are going on all around us continually. These various changes may take place at a number of different temperatures, and large changes in energy may take place with no change in temperature, as when water absorbs the latent heat of evaporation, which you will remember is 970.4 B.t.u. per pound at atmospheric pressure."

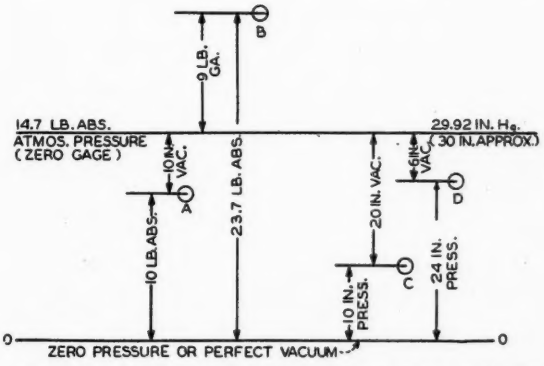
"You mentioned specific weight and specific volume of gases and steam, G. F." the Chief interposed. "I remember that we discussed them before, but just for review, define them again, will you?"

"Specific weight is weight in pounds of one cubic

foot, and specific volume is volume in cubic feet of one pound. Now to continue,—do you remember the three ways in which heat is transferred, Chief? No bluffing, now!"

"I remember that radiation and convection are two of them, but to be honest about it, I don't remember the third, or just what is meant by radiation and convection," he replied.

"The three ways by which heat is transferred are radiation, convection and conduction and in many cases all three will work to some degree simultaneously. Radiant heat is that which is given out in the form of rays, something like light rays, except that they are invisible. The heat from the sun is radiant heat. The heat you get through the open door of a furnace or from a red hot piece of steel is also radiant heat. An object placed in the path of radiant heat rays will intercept the rays and cast a shadow,—that is shut off



Diagrammatic comparison of the various methods of measuring pressures

the rays. Heat transferred by convection is carried by a gas or liquid. For example, a radiator, in addition to giving out radiant heat, heats the surrounding air, which circulates and carries heat to other parts of the room. In a boiler, the water next to the heating surfaces absorbs heat, causing the water to circulate and carry the heat to all parts of the body of water.

"Conduction is the transfer of heat by travel through a solid or liquid. If you hold a piece of copper wire in your hand, with the end in a gas flame you will quickly feel the heat in the end you hold, due to its being conducted through the metal. All three methods are utilized in the generation of steam in a boiler,—radiant heat rays strike the surface visible from the fire, and heat by convection from the hot gases of combustion also heats the surfaces, the heat traveling by conduction from the gas side to water side of the boiler tubes and plates. There the heat is again carried by convection from the heating surfaces throughout the boiler.

"Heat will always travel from a warmer to a cooler temperature except where it is forced 'up-hill' so to speak by refrigerating equipment."

"What do you mean by 'forcing heat up-hill'?" the Chief interrupted.

"That is a fair question, Chief, and I think you will see its meaning clearly if you will compare the refrigeration cycle with the cycle of steam generation and use in a heating system. 'Forcing heat up-hill' is simply reversing its natural tendency to flow from hotter to cooler by absorbing heat at a lower temperature and discharging it at a higher temperature. To illustrate, follow through briefly the refrigerating cycle,—liquid refrigerant goes to the evaporator (the cooling coils) where it absorbs the latent heat of evaporation, and is vaporized, with probably some superheat. The evaporator corresponds to a steam boiler. The vapor then goes to a compressor which raises the pressure and consequently the boiling point or condensing temperature. You remember that with saturated steam, temperature and pressure always correspond. The same fact is true for any refrigerant,—there will always be some definite condensing temperature for a given pressure. The pressure has to be such that the corresponding condensing temperature will be well above the temperature of the available condensing medium, air or water, usually water. The difference between the refrigerant condensing temperature and the cooling medium temperature must be great enough to cause sufficient heat transfer through the condenser walls to bring about the condensation of the vaporized refrigerant, by absorbing its superheat if any and its latent heat of evaporation. The condensed refrigerant then flows to the receiver and the cycle starts over again. The condenser would correspond to direct radiation in a heating system, being the point where the heat which is picked up by the evaporator (or boiler) is discharged from the system,—at a higher temperature, in the refrigeration cycle, requiring power in-put.

"Now what happens is this,—heat is absorbed at, say 35 deg. in a cooler, and discharged into condenser water at say 75 deg. or in the case of a small unit cooled with air it might discharge its heat at 100 deg. or higher, with a consequent higher pressure, and consequently more power input. Thus you will see that by putting in power and with suitable equipment heat can be made to flow from a cooler temperature to a warmer temperature, or 'up-hill'."

"Okay, G. F.," the Chief said. "Now what is this stuff about pressure that you were going to tell me? Any dumb-bell can look at a pressure gage and read the pounds of pressure, or vacuum-gage and read the vacuum, or a combination gage and read either one, though not at the same time of course."

"All right, Chief. Now get this straight," I returned. "There are at least nine common ways of expressing pressure, any one of which you may see in articles or text books, and most of them in every day work, specifications, etc. Here they are. Write them down,—

Pounds per square inch, gage (ga.)
Pounds per square inch, absolute (abs.)
Inches of mercury, pressure
Inches of mercury, vacuum
Pounds per square foot, absolute
Inches of water, pressure
Inches of water, suction or draft
Feet of water
Atmospheres

"We will consider the first four, first. I will draw a little diagram which will make each one clear to you.

"Pounds gage is what you are used to reading on your steam, air and water pressure gages, and unless specified differently, a given pressure in considered as gage pressure, though to be on the safe side, I always write the abreviation 'Ga.' or 'Abs.' after pressures. Pounds absolute is merely gauge pressure plus 14.7 lb. per sq. in., or for convenience, except in test or research work, it is usually sufficiently accurate to add 15 lb., if the given pressure is above atmospheric. You can see from the diagram that there are two starting places or reference points. From atmospheric pressure you can measure either up or down. From zero pressure, or a perfect vacuum, you can only measure up. Look at Point B on the chart. This will be 9 lb. above atmospheric or 23.7 lb. above zero pressure. There is nothing confusing about that, is there? Pressures below atmospheric are more likely to fool you. Point A, for example could be specified in three different ways, —10 lb. abs., 10 in. vacuum, or 20 in. Hg. pressure. You will recall that 'Hg.' is the chemical symbol for mercury and is used just to save writing out the whole word 'mercury.' In the same way, Point C could be specified 5 lb. abs., 10 in. pressure, or 20 in. vacuum,—and for Point D,—24 in. of pressure, 6 in. of vacuum, or 12 lb. abs. These figures are assuming an atmospheric pressure of 15 lb. or 30 in. of Hg. One pound per square inch is equivalent to 2.04 in. of Hg., but for convenience is often taken as 2 in. Hg. per pound pressure."

"Couldn't you give vacuum in pounds?" inquired the Chief.

"Yes, Chief, we could, but it is not customary and three ways of specifying a given pressure below atmospheric ought to be enough for you anyway, without bringing in a fourth one."

"Another question, G. F. Why do vacuum gages read in inches of mercury, vacuum,—combination gages read in pounds, gage, and inches of mercury, vacuum, —yet all steam tables read in pounds absolute, or in both pounds absolute and inches of mercury pressure for pressures below atmopsheric?"

"Just a matter of custom, Chief," I replied. "But it is also logical and convenient. Stop and think how your pressure gages work. You have your Bourdon tube which will move the pointer to zero when the pressure inside the tube and outside are equal, or atmospheric. As far as the operating man is concerned, atmospheric pressure is a good starting point, and you will have no pressure until you get above atmospheric. In heating work, your pressures will be a little above or a little below atmospheric, and the needle will point to a pressure in pounds above zero (atmospheric) or inches of mercury below zero (atmospheric), measuring up or down from zero pressure, gage. In the steam tables, zero absolute seems the logical place to start and go right up from zero to critical pressure, in pounds, absolute."

"Keep in mind that pressure inside the Bourdon tube merely moves the end of the tube, which in turn moves the pointer of the gage. Under the pointer, any suitable unit can be used to measure the movement (with proper calibration),—pounds, inches of mercury, feet of water, or atmospheres,—starting either from zero pressure absolute, or from atmospheric. It is just a matter of the size of the divisions, and the starting point.

"Going on down the list,—next is pounds per square foot, absolute. This unit merely is 144 times the pressure in pounds per square inch absolute. It is not in common use, but is used in some theoretical calculations and the constant used in Charles' Law is sometimes given in pounds per square foot absolute. Don't worry about what Charles' Law is just now,—we will go into that in one of our future discussions.

"Inches of water pressure, or suction is used a great deal for pressures varying slightly above or below atmospheric pressure. You have draft gages in your boiler room and of course you know that when a draft gage shows say 0.15 in. that you are reading a pressure indication just below atmospheric. Let's see what that means in pounds per square inch. One pound is equivalent to 2.309 feet of water, or 27.71 in. at 62 deg. F, or if you connected a pressure gage with the bottom of a tank with 27.71 in. of water in it, having the gage level with the bottom of the tank, the gage would read 1 pound per square inch. Therefore, 0.15 in. of draft is equivalent to 1.05/27.71 or 0.0054 lb. per sq. in. which is a very slight pressure difference as pressures go, but you know how effective that tiny pressure drop can be in moving air. In boilers with natural draft, all the air presures will be below atmospheric, while with forced draft there will be pressures above atmospheric, and with induced draft, the pressure on the suction side of the blower will be less than atmospheric and on the discharge side above atmospheric.

"In ventilating systems we will usually have above-atmospheric pressures, and in exhaust systems, below-atmospheric pressure. In measuring the flow of air we get static pressure, total or dynamic pressure and velocity pressure by means of a Pitot tube, all given in inches of water.

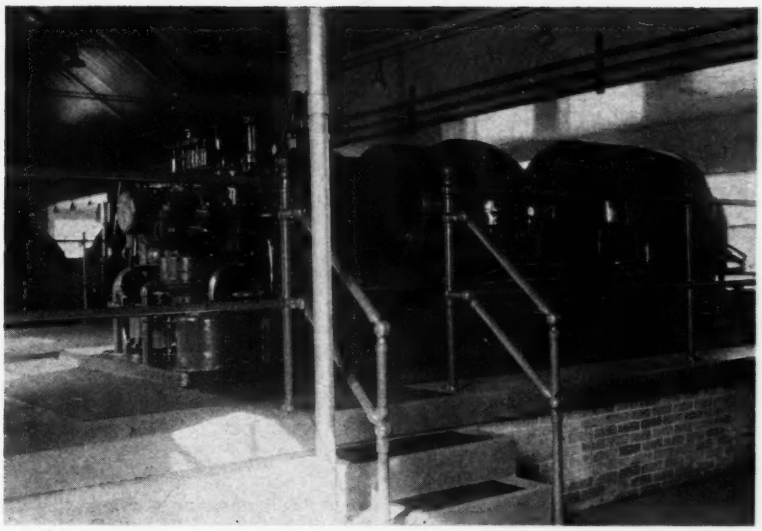
"Feet of water is used a great deal in connection with pumps and hydraulic turbines. In some cases, 'feet of water' means actual difference between water levels, but more often it means the equivalent of a difference in levels, being made up of resistance to flow due to friction, some difference in levels, and possibly in addition the actual performance of work in a hydraulic machine. As I told you before and as you may have known before, 2.309 ft. of water is equivalent to one pound per square inch pressure. So each foot of water pressure is equivalent to 0.433 lb. per sq. in.

"The last one on the list is 'atmospheres.' With your usual perspicacity, you will recall at once that a given number of atmospheres means the number of units of 14.7 lb. per sq. in. each, above atmospheric pressure. Naturally, the units being large, 'atmospheres' is used to measure the high pressures used in connection with carbon-dioxide (CO_2) refrigerating systems.

"Now, Chief, I haven't tried to give you anything particularly new, but I think you must admit that a review like this now and then will not hurt any one. Books could be written about the subject matter we have lightly touched upon, but I know that you know most of the details, if you will just stop and think of them, so we will dispense with book-writing, and I will be on my way."

Municipal Plant *adds* Turbine Unit

Celina, O., increases generating capacity and operating efficiency by the addition of a new 750-kw. Allis-Chalmers extraction-condensing unit



OHIO HAS MANY fine municipal plants, none better managed and better kept, however, than that of Celina, which although not the largest in the state by far, has, under 14 yr. of able management by Roy Cook, city manager, shown a steady increase in service rendered the community at a constantly decreasing cost of service. Nor has the distribution system been neglected and Celina is one of the few communities recognizing the value of capacitors for power factor correction, three banks being used to maintain a power factor of about 90 per cent.

In addition to supplying the city distribution system, the plant sells low pressure steam for heating and pumps the seven wells which supply the city with water. These wells are pumped by a power jack driven by a steam engine which is operated for heat balance purposes to maintain the feedwater temperature during odd hours of the day when the turbine load, and consequently the extraction steam pressure, is low. Heating steam is now normally supplied by extraction from the turbine although formerly it was supplied by non-condensing engines. Four non-condensing engine units, totaling 1150 kw., are installed, the most recent being an Allis-Chalmers 18 and 32 by 42 in. cross compound installed in 1927. This engine drives an A-C 500 kw., 2300 v., 2 ph., 60 cycle generator at 120 r.p.m.

In the boiler plant are three 160 lb. saturated steam boilers, one 350 hp. Erie City, one 300 hp. Union and one 300 hp. Heine. The first two are fired by Type E stokers, the last by an Erie City pulverizer, driven by an Allis-Chalmers motor. Bailey boiler panels with Bailey boiler meters and multipoint draft gages are used and the last boiler is equipped with a McDonough control. Forced draft is by means of an American fan V-belted to an Allis-Chalmers motor. Boiler feed make up is taken from the St. Mary's Lake and runs about 14 gr. per gal. hardness, considerably softer than the well water. It is softened in a Permutit Zeolite softener and heated in a Swartwout deaerating heater. Three horizontal duplex steam pumps are installed for boiler feed purposes, two Dean Bros. and one Gardner-Denver.

Coal is elevated from the track hopper by bucket elevator and delivered from storage to the boot of another elevator by screw conveyors. The bucket elevator discharges to a Buffalo scale and from the scale is delivered to the various stoker or pulverizer hoppers by screw conveyors. An emergency feed to the pulverizer is provided by a separate elevator which can be fed from a wheel barrow.

The new unit, recently completed at a cost of $53,160, is an Allis-Chalmers 3600 r.p.m. turbo-generator rated at 750 kw., 0.8 p.f., 2300 v., 2 ph., 60 cycle, with a direct connected exciter. Although operating at 150 lb. saturated steam pressure, the turbine is built for 400 lb. pressure so that it can be easily converted later if high pressure boilers are installed. The turbine is set over a 1500 sq. ft. Allis-Chalmers condenser, the shell and hotwell of which are of welded steel plate, the water boxes and heads of cast iron. Tubes are rolled at both ends to reduce leakage and belled at the inlet end to reduce the friction losses. Expansion due to temperature changes is taken care of by means of a floating head and a welded expansion joint shown in detail at the right of Fig. 1. The same type of joint is used with the welded steel exhaust connection betwen the turbine exhaust and condenser inlet. A shop view of this piece is shown by the photograph at the left of Fig. 1.

The 3 by 1½-in. A-C hotwell pump has a capacity of 36 g.p.m. under a 75 ft. head when driven at 1740

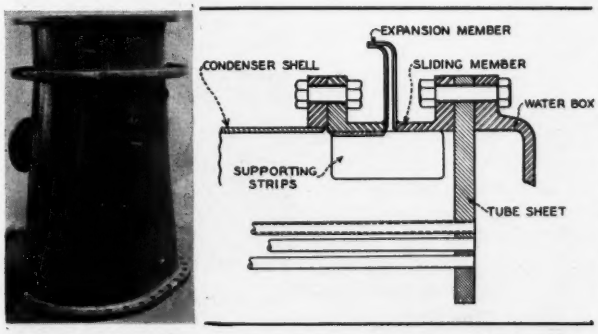


Fig. 1. Condenser tubes are rolled at both ends and expansion taken care of by a welded expansion member in the shell. The photograph at the left shows how this same design is applied as an expansion joint in the exhaust connection.

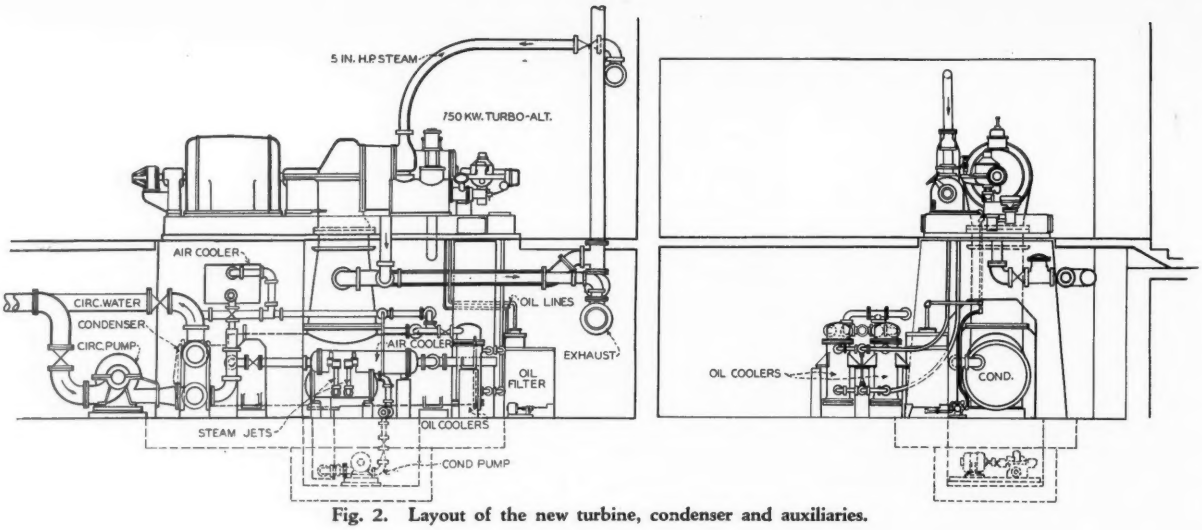


Fig. 2. Layout of the new turbine, condenser and auxiliaries.

r.p.m. by an Allis-Chalmers 5 hp., 440-v. motor. The hotwell level is held constant by a Fisher float control actuating a valve in the discharge line of this pump. Air from the condenser is removed by a Croll-Reynolds two stage, twin, steam jet equipped with an air flow indicator and supplied with 125 lb. steam through a Fisher reducing valve. Condensate from the ejector condenser and drainage from the bleeder line ahead of the Atwood-Morrill check valve is drained back to the main condenser hotwell through Fisher traps. The turbine valve chest is drained by a Nickerson trap back to the feedwater heater.

Instruments

Operating instruments include a Bailey integrating and recording steam flow meter, Taylor indicating thermometers and mercury vacuum gage, a Biddle vibration tachometer and Consolidated-Ashcroft-Hancock pressure gages. The Griscom-Russell air cooler and duplicate oil coolers are supplied with water from the circulating pump high pressure side. Other equipment includes a Bowser oil filter and a Cutler-Hammer field rheostat, the latter located above the switchboard, a 9 panel G.E. board complete with G.E. instruments, synchroscope and voltage regulator.

Condenser cooling water is pumped by an Allis-Chalmers 10 by 8 in. circulating pump discharging 1725 g.p.m. against a 68 ft. head and driven at 865 r.p.m. by an Allis-Chalmers 40 hp., 440 v. motor. The plant being located a considerable distance from the lake, this water is cooled by a 2000 g.p.m. Hoffman tower built in two sections, each section with a Hartzell propeller fan driven at 1200 r.p.m. (tip speed 1300 ft.) by an Allis-Chalmers 15 hp., 440 v. motor. The low tip speed is conducive to silent operation.

Piping

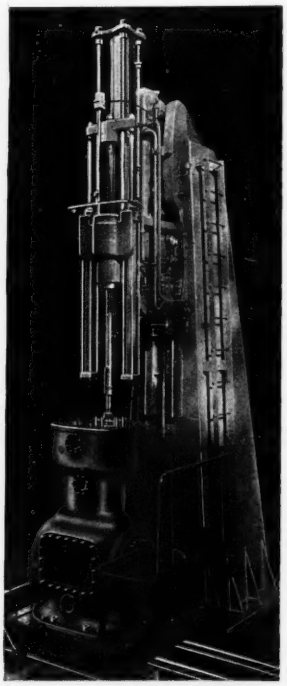
All piping and valves throughout the new section of the plant are Crane and the motor starters Condit. Compressed air for general service around the plant is supplied by a Worthington 4½ by 5 in. single stage, vertical compressor, close belted to a G.E. 5 hp., 220 v., 1000 r.p.m. motor. Space for the new turbine was made available by removing an old engine unit and to avoid excessive excavation for the condenser well, the turbine was set higher than the regular floor level as shown by the photograph. The sump in the condenser well is drained by a Myers self-contained, float controlled type sump pump driven by a ¼ hp., single phase Emerson motor.

Finishing Compressor Cylinders

Close limits demanded by modern machines makes it necessary to utilize all the skill of the machine tool maker's art. This is particularly true of cylinder finishes for engines or compressors and honing, because it gives such uniformity and accuracy, is becoming increasingly popular as it not only takes out high spots but corrects lack of roundness or taper in the bore. The importance of this from an operating standpoint cannot be overemphasized.

A honing machine to handle columns up to 8½ ft. in height was recently designed and built by the Frick Co. for the purpose of finishing the cylinders of their vertical refrigerating compressors. This machine, driven by a 15 hp. motor is said to be the largest of its type in existence.

It stands 20½ ft. high, and has a 5000 lb. counterweight to balance the working head which can be moved up and down at speeds varying from 5 to 55 ft. per min. The rotary motion of the spindle can be given any one of nine speeds. The honing tool carries a series of long narrow stones which are pressed gently outward by springs and is driven through a jointed member which allows it to float in the cylinder.



Honing machine for compressors

Case Studies in Power Economics

Conducted by
ZUCE KOGAN,
Kogan Industrial Service
Chicago, Ill.

Plant saves $1200 annually in fuel handling. Possibility revealed by plan drawing of factory

IN ALL OUR previous articles we have stressed the importance of taking advantage of existing equipment in order to realize a saving either in fuel or power. It seems to us that such opportunities of which one may take advantage exist in every plant, both small and large. It is only necessary for those responsible for operation of the plant to keep one object in mind, and that is to try to reduce expenses, be it either in fuel, power or labor, and likely as not, something that has been used and neglected will find its rightful place in the organization with gratifying results.

We wish in this article to tell about a plant where, by putting a railroad siding, which was practically in disuse, into service, the cost of handling coal was reduced to almost nothing.

The plant, in which household appliances were manufactured, was U-shaped. Two railroad sidings adjoined this plant, one on the outside of the U and the other on the inside. Years back they had a shipping platform close to the siding on the inside of the U. Due to change in certain manufacturing processes, however, they needed that shipping-room space and the entire shipping was moved to adjoin the siding on the outside of the U. In the meantime, the inside siding being practically in disuse, was rusting away.

The boiler room was located in the cross-bar, so-to-speak, of the U and towards the inside of it.

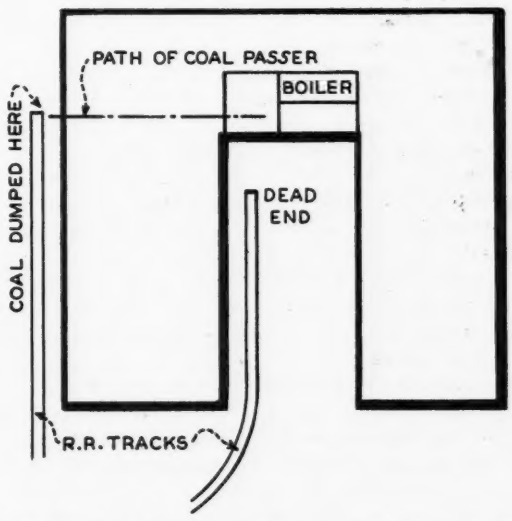
Coal was purchased in carload lots to the extent of a car a day. The coal was brought on the siding outside of the U. It was dumped there and three men per shift for two shifts per day wheeled in the coal by means of wheelbarrows for a distance of 400 ft. and dumped it in front of the boiler. All that these six men could do in the course of 17 hr., or for a total of 51 hr. a day, was to unload one car of 50 t. of coal. The labor charge was 40c per hour, or to unload a car of coal the cost was approximately $20.

In spite of the fact that there was an annual charge of approximately $6000 for unloading the coal, the board of directors could not see the appropriation of $12,000 to $15,000 that was necessary to install a conveyor to get the coal over, as, besides the money question, there was also the occupation of valuable space by the conveyor and the making of some drastic changes in the rearrangement of some equipment that was in the way. It was contemplated that a change would be made sometime in the far future, when business would be considerably improved and new boilers needed, the boiler room would be moved to within a reasonable distance of the siding.

Shortly after that decision was made, we were surveying the plant with the object of finding methods of bringing about economies in the steam generation and its utilization. When we expressed our surprise to the plant superintendent about high cost of coal unloading he gave us the reasons stated above why no change was being made. We, ourselves, looking around the premises and noting where this conveyor would have to be carried, saw the impracticability of its installation. That high expense on coal unloading, however, bothered us considerably and we felt that something should be done.

We examined the plant, scrutinizing practically every inch of it, and in spite of the fact that we noticed the unused siding, we could not connect it with the problem and we dismissed this auxiliary siding as being useless, just as the plant management had done. We, ourselves, gave up the job as being hopeless and we continued to gather information regarding the steam generation and utilization with the object of finding economies therein.

It was a casual glance on the perspective drawing with cut-aways of the plant, supplied by the insurance company, which brought to us with a forceful shock the realization that something could be done to elimi-



Plan of factory building showing boiler room location and railway track facilities

nate or to reduce that $6000 yearly expense of coal unloading with a minimum expenditure and with an installation that would be practical and feasible, involving no drastic changes. The sketch herewith is what we saw.

The boiler room, as seen from the sketch, is near the inside of the U and there is enough space to allow a car to enter, leaving enough space between the boilers and the car, where a bin to hold at least one car of coal could be erected.

After seeing this, everything seemed quite simple. Naturally, the first thing to do was to break out an opening in the wall next to the boilers so that passage could be had from the railroad siding to the inside of the boiler room. That in itself would have shortened the distance for the men with the wheelbarrows to about one-third. A still better arrangement would have been to lengthen the siding and to extend it into the boiler room parallel to the boilers, erect a wooden bin to hold more than a car of coal, and to procure a coal elevator in conjunction with the portable conveyor, so that by purchasing coal in hopper bottom cars, the coal could be unloaded directly on the portable conveyor which would convey the coal to the bucket elevator and the bucket elevator in turn would dump it into the wooden bin.

On the last arrangement it was estimated that the cost would be in the neighborhood of $1500 which consisted of $1100 for the bucket elevator, its erection, and the portable conveyor; and $400 for extending the track into the boiler room, to construct the wooden bin, and to break out an opening in the boiler room wall to allow the entrance of a coal car. A few boards at the bottom of the wooden wall of the bin, next to the boiler were to be removed so that the fireman could procure coal from the bin directly.

The first arrangement, which required only the breaking out of the wall to allow passage for men with the wheelbarrows, was not deemed advisable, as it meant the dumping of coal inside the U and the danger of spotting with coal dust the enamelware inside the building, as the windows had to be kept open there practically all the time.

However, no objection was raised to the other arrangement and it was carried out as we suggested.

This installation brought about the complete elimination of labor for coal unloading. It cleared the outer siding and thus interference with the regular shipment of goods was eliminated. Besides, a car of coal was unloaded in the course of 1½ hr. The amount of power involved was only that of two 3 hp. motors, one driving the bucket elevator and one, the portable conveyor for 1½ hr., the power amounting to a few cents a day.

The arrangement described here has been running for about 2 yr., during which time the cost of handling coal has been reduced by approximately $1200.

This reduction was brought about by merely taking advantage of the peculiar conditions of the plant and the unused equipment plus an investment of $1500.

Diesel Engine Insurance

H. J. Vander Eb of the Hartford Steam Boiler Inspection & Insurance Co. points out some pertinent factors in Diesel maintenance to the Oil & Gas Power Division of the A. S. M. E.

POWER-PLANT INSURANCE has a long history. From nearly the beginning of power generation, hazards of disastrous explosions and costly failures in the power plant have been insured against and no doubt they always will be. All insurance is primarily based on the sound economic principle of the widest possible distribution of the burden of accidental losses.

It is only natural, therefore, that with the rapid development and the recent strong growth of the internal-combustion engine in the power field there is an increasing demand for insurance protection at a reasonable premium, whereby engine owners can remove the uncertainty of having to meet unexpected losses from costly breakdown accidents, which in some cases wipe out nearly the entire engine investment and may cause damage to surrounding property as well as injury to persons.

Experience of insurance companies with Diesel engines has been unfavorable and it is the purpose of this paper to set forth some of the basic reasons why breakdown insurance rates on Diesel engines, although they are as low as 1/10 of a mill per rated brake horsepower hour, have thus far been somewhat higher than the rates on other types of power engines.

Existing premium rates on Diesel engines are undoubtedly causing some insurance sales-resistance and, consequently, the percentage of insured Diesel engines in the United States is small. However, speaking of about 7000 engine years from the experience of this one company alone, the necessity for these higher rates can be removed when better operating standards and practices are more generally established. This experience brings out clearly that there is great room for improvement in operating standards and practices.

Based on the principle that most of the peril of accidents, to which mechanical structures are exposed, are due to their inherent faults or to developed weaknesses, the insurance company makes a systematic study of each risk and regularly during the insurance term. In so doing, they aim to avoid insuring engines that are not normal installations and thus promise to give poor experience. No insurance company knowingly insures an abnormal risk either from the standpoint of the physical condition or care.

Comparing the development of the steam engine with that of the internal-combustion engine, one is impressed with a striking difference. With the steam engine there was and still is great conservatism and ample factors of safety, making for long life. Steam engines are now being operated successfully and economically that are 40 and even 60 yr. old, the cylinders having been rebored 3 or 4 times.

In contrast to this, the trend with internal-combustion engines, and particularly the compression-ignition engine, has been unmistakably to regard them as, what might be termed, a semi-permanent piece of power-plant equipment, in which the cost of rapidly deteriorating parts is weighed against a high economy obtainable in fuel consumption and in other operating supplies. This has been strongly influenced by recent extreme competitive conditions in manufacturing and by the introduction of the so-called, high-speed, compression-ignition engines. The result has been that certain important working parts of Diesel engines are comparatively short-lived.

With short-lived equipment it frequently is hard to differentiate clearly between maintenance repairs and repairs arising from accidental breakage. There is a wide zone of typical failures of engine parts that occur because of fatigue, or age cracking or burning, which nevertheless, are somewhat accidental because of their occurring earlier than expected and are caused under abnormal conditions. It is principally this feature which has forced the insurance companies to adopt the rate levels now existing.

It has been suggested that the rate structure might be based on various credits for safety devices but long experience in the power-plant field has shown clearly that the mere presence of protective devices is not a guarantee against disastrous accidents. The main reason for this is that any automatic device depends on the human element, and, furthermore, the devices themselves are subject to accidental derangement.

Obtainable protective devices are desirable and useful, if used intelligently, and it is not the intention to deprecate their use. Indeed it is the practice of the insurance companies to insist on the installation of proper protective devices before a risk is considered normal. However, owing to the great variety of plant conditions, it is not feasible to universally apply the usual protective devices and thus permit reductions in the rate. Hence, a flat rate for insurance on all normal risks and no insurance for abnormal risks.

A normal Diesel breakdown risk, broadly stated, has been considered, thus far, to be one where the following points are met in accordance with the prevailing operating standards:

1. It is to be in good physical condition.
2. There must be at least one automatic device on the engine to keep the speed in safe bounds when the load drops.
3. The load is to be at all times somewhere within the rated capacity of the engine.
4. The effectiveness and reliability of the cooling system to be such that the cylinder liners, pistons and cylinder heads are not heated beyond reasonable limits, so that these parts may have the normal span of useful life.
5. Thermometers and other devices are to be installed for the proper observation of operating temperatures, as found necessary.
6. An operator in attendance who is conversant with the operating requirements of the plant and the type of engine used.

With the experience dealt with in this paper it is not possible to catalog all the factors involved in statistical array, and the statements made herein are based merely on broad observation and the making of comparisons between engines that have an excessive number of enforced shut-downs and other engines that are entirely similar but, operating under more favorable conditions that gave a decidedly more favorable experience. By making these comparisons, the three main factors that clearly stand out as having influenced the unfavorable experience of insurance companies are: 1. Overloading; 2. faulty cooling systems; 3. unsuitable fuel.

Insurance companies' experience tends to show that a somewhat too optimistic rating of some of the Diesel engines made in this country is responsible to a considerable extent for the overloading evils. This has led to excessive operating temperatures and an excessive frequency of "stuck-piston" accidents. It would undoubtedly benefit all concerned and eliminate a great deal of dissatisfaction of Diesel users if a more conservative basis of rating could be agreed upon for most of the Diesel engines now in use.

Existing "Standards of the Diesel Engine Manufacturers" (1930) quite properly includes the following statement: "While Diesel engines are rated at powers which allow of some overload capacity for short periods, it is poor engineering to count upon this overload capacity to handle routine peak loads."

Whenever this is done, the useful life of the cylinders, cylinder heads and pistons can be discounted well below the normal expectancy with the attending high frequency of enforced shutdowns. It appears very desirable that an even more conservative attitude be included in the "Manufacturers' Standards" as regards "overload capacity" and, in fact, strong warning should be given not to load engines beyond their rated capacity at any time.

Automatic Control

IN THE ARTICLE beginning on page 33 of the January issue, it was stated that "Richmond Station, an example of modern control, is also of interest because of an innovation in color, the control panel being a light color. The panel is of stainless steel and if in practice the reflection qualities are not satisfactory, a light colored paint will be applied."

It has been drawn to our attention by W. B. Morton, Inside Plant Section, Electrical Engineering Division, of the Philadelphia Electric Co., that the two control boards installed for the new 600,000 lb. per hr. boilers at Richmond are constructed of ⅛ in. stretcher level steel, which is finished with aluminum lacquer to produce the light finish.

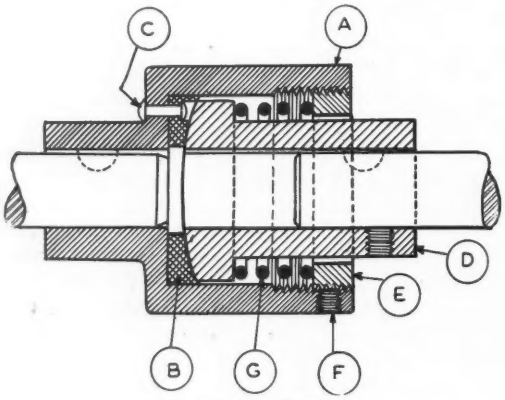
Stainless steel was considered for these switchboards, but was not used because of the possibility of highlights due to its light reflecting qualities. In order to obtain some experience with the application of this metal in switchboard construction, a small board controlling the fuel preparation equipment was constructed of stainless steel. The decision to use aluminum finish for the boiler control panels resulted from experiments with colors, lighting effect and scale models which are described at length in an article, in the June 1935 issue of the Electric Journal, Light Colored Switchboards and Control Room Lighting.

Readers' Conference

Coupling for Small Drives

IN THE DESIGN of fractional horsepower compressors, pumps, and other mechanical drives, a safety device should be employed to prevent the prime mover from driving the secondary mechanism beyond a point where damage may result to the secondary mechanism, which in many instances is the more expensive of the two.

In many such instances the writer has employed the coupling shown in the enclosed illustration and has found it to give very satisfactory results.



Cross Section of Clutch

As shown, the device consists of an outside housing A, into which has been riveted the asbestos concave washer B, by means of the rivets C. The male half of the housing is convex, as shown at D and fits the concave surface B. Behind the part D is a spring, the force of which is determined by the amount of compression as adjusted to by the threaded washer or collar E. This collar is locked in place by the brass set screw F. It will thus be seen that the amount of torque which can be developed is determined by the pressure exerted by spring G which can be increased or decreased by the position of the collar E.

Another feature of this type of coupling is its ability to adjust itself for slight misalinements of the two coupled members.

New York, N. Y. JOHN A. HONEGGER,

About Check Valves

AN ENGINEER often installs a check valve and then thinks he can go away and the gadget will continue to function indefinitely. We wish to show, however, that a check valve is not always the correct answer to cure a certain condition,—that a check valve should be carefully selected to meet the conditions under which it is to operate,—check valves of certain kinds often deteriorate in use so they will not function,—often they need periodic inspection to determine their condition and to be sure that they will not fail at a critical moment and cause an interruption to the service.

Check valves were formerly installed universally in the returns to each boiler in a battery of boilers used for steam heating where the returns came back by gravity and when so used they would often stick in the open position or because of scale getting under the seat and because of their not functioning properly there would be caused surging between the various boilers in the battery, in which case there existed a hazard that when one boiler was cut out of service at its stop valve and ceased to produce steam it would gradually fill up through its leaky check valve and produce low water in some of the other boilers. There was also the hazard that if there was but a single boiler someone might shut off the stop valve, it would be forgotten and fired up again in which case the water would be pushed out into the return mains and low water produced.

It has long been known by operating engineers that a by-pass from inside of the main stop valve to the inside of the main return valve of such a heating boiler does away with the necessity of using any check valves at all and makes the system fool-proof. Also there is a system of piping devised by the National Board of Boiler and Pressure Vessel Inspectors showing how such heating boilers may be installed in a battery without the use of check valves and making them fool-proof as far as dividing the water between them is concerned,—but unfortunately most of the engineers who do the installing are ignorant of this scheme or indifferent to its use.

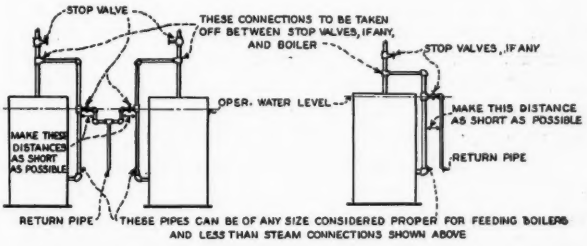
This method is shown in the accompanying illustration. The two salient points upon which this method depends for its success are a by-pass inside the stop valves of the supply and return, connecting the steam space with the water space and thus equalizing the pressure in each boiler separately, and the feeding of the returns into these by-passes at the water level. This method is remarkably effective in causing both boilers to carry the same water level irrespective of whether they are both fired equally. Moreover, one cannot drive the water out of one boiler into the other merely by shutting a valve. The only undesirable thing that can happen is the producing of a water hammer in the feed outlet, which results from shutting off one of the stop valves while the boiler is under steam, in which case, however, the water hammer calls one's attention immediately to the error.

Of course all practical engineers know that high-pressure boilers must be protected from the hazard of check valves going bad while the boilers are in operation and this is done in standard practice in plants where the service must be continuous by having two ways of feeding the boilers, or by duplicate feed-water mains. The check valves have stop valves

installed between them and the boiler and between them and the feedwater headers so that an inspection or a repair can be made at any time while the boilers are in service.

Check valves are made in a number of patterns which differ in their application, that is, they are not all equally useful for the same service. The commonest type used for high pressure boilers is the horizontal hinged type sometimes called a "flap-valve." There is the vertical type of check valve which must be installed in a vertical position and will not function correctly unless it is properly installed. These may be of ball type or rising stem with guide and in use may stick in the open position or get cocked on their seat or become leaky through wear.

It is a common mistake to omit check valves on a city make-up feed line. Some day the city mains may be drained for repairs, and thus cause a reversal of flow from the boiler. Also check valves are sometimes omitted in feed lines from pumps, which eventually leads to trouble from steam coming back into the


STOP VALVE
THESE CONNECTIONS TO BE TAKEN OFF BETWEEN STOP VALVES, IF ANY, AND BOILER
STOP VALVES, IF ANY
OPER. WATER LEVEL
MAKE THIS DISTANCE AS SHORT AS POSSIBLE
MAKE THESE DISTANCES AS SHORT AS POSSIBLE
RETURN PIPE
RETURN PIPE
THESE PIPES CAN BE OF ANY SIZE CONSIDERED PROPER FOR FEEDING BOILERS AND LESS THAN STEAM CONNECTIONS SHOWN ABOVE

Recommended piping for heating boilers

pump whenever the pump valves become leaky. Now and then some one installs a horizontal check in a vertical position, or a vertical check horizontally. Plumbers often make the mistake of trying to serve two low-pressure boilers with one check valve, whereas there should be a separate check valve in the line to each boiler; this mistake leads to surging between the boilers. With only one check valve and no separate cutoff valves in the steam lines to the boilers in the battery, as I found in a recent case, the operation must be somewhat complicated and full of surprises.

Often someone installs an auxiliary feed line from city water supply to boiler and leaves out the check valve. We came along one day where they had the street water mains shut off and a ditch open for repairs. We went in nearby to inspect a heating boiler where the janitor had just noticed his water was a little low and he opened the auxiliary feed line and having no check valve in this line he was letting the water out of his boiler into the street ditch.

The other day we found a plumber had installed a vertical check valve of the ball-check type where the water came downward from an overhead main and the water passed through it in the direction shown by the arrow on the outside of the case, but in this position the ball being held on its seat only by gravity would always remain open and never function properly as a check valve. Horizontal check valves are also often found installed in a vertical position in a way that they cannot function. A vertical ball check can be used only when the feed is upward from below.

The other day we noted an installation where they had a 40 hp. three-phase slip ring type of induction motor driving a centrifugal pump which raised water from a deep well to the tank on top of a high building the motor being stopped and started by a float type switch in the tank. There was a common "flap-valve" check ahead of the pump. When the motor was cut off suddenly and stopped almost instantly there was a backward surge of the high column of water which closed the check valve with a violent bang; no doubt it will cause it to batter out its seat in a few months or break the flapper. The only check valve I ever saw that would stand up under this service was a type with the flapper hinge extending through the case and fitted with a dash-pot so that the valve would have to close gently. Be careful to select your check valve to suit the service.

Chicago, Ill. C. C. CUSTER.

Where Silence Is Essential

FOR SOME weeks an article entitled "Where Silence is Essential," Page 648, November issue, has irked me to a point where I must write you and get it out of my system.

The first paragraph mentioned eight or nine white clad engineers. That's the part that irks.

The general trend of the story puts the date in the early part of the century when we burned coal and had mostly reciprocating jobs, and secondly, it would seem to be a Limy "English" vessel, and Mark Bell tries to cram eight or nine white clad engineers down my throat with such a combination. Please ask him what ship?

As for the main issue "Silence," I am in perfect accord. In the Navy we used to say there were only two people aboard who whistled, namely "Bos'n's Mates" and Dam' Fools, and we had no B.M.s in the black gang.

Rosedale, N. Y. CARL O. KLOTZ.

Elementary Lesson in Soldering

A SIMPLE THING, which many engineers know little or nothing about, and is of no little importance at times, is the care and use of soldering irons or coppers. The first thing is to keep them in a condition such, that when the iron is applied on a seam or joint the solder will flow evenly on the work, instead of forming in drops and refusing to flow or else following the iron.

First see that the point, or 4 sides used in applying solder to the work, are absolutely clean. If the iron is old and rough, they can be dressed up with a file until smooth, clean copper appears. Have a block of sal-ammoniac which can be obtained for that purpose. Heat the iron as hot as possible, without burning, and rub it on the sal-ammoniac at the same time applying some solder to the copper and the solder, melting, will run down on the sal-ammoniac. Move the copper back and forth and a coating will adhere to the copper, leaving it smooth and bright. It does not require a great amount of practice to become expert at tinning a soldering copper. If the block form of sal-ammoniac cannot be had readily, the powdered form will do just as well.

Another thing is a flux to apply to the work, before trying to solder. Muriatic acid, cut by putting in all the zinc it will eat up or in the absence of zinc, galvanized sheet iron, makes a flux that can be used on practically any job around an engine room. Have soldered a crack in the outside of the water jacket of a 12 by 12 in. air compressor, steel angle irons, galvanized sheet metal to black iron plate and various other combinations of sheet metal, strap, angle, and cast iron with the above flux. Don't however try soldering aluminum with it. Keep your iron well tinned, don't heat too hot, use a good flux, clean the work thoroughly and have a piece of clean wool cloth, free from oil or grease, and occasionally wipe the iron off with it.

One job that many fall down on is soldering the joints in overhead galvanized iron piping. The top and sides are not so bad, but the under or bottom side is where the kink comes. The boy not in the know will take his iron "as is" and the solder will usually run away from the pipe and try to all get on the bottom side of the iron. Well, next time this happens just file the copper on 3 sides until there is no tin left on it, leaving the other side tinned and you can solder over head to your heart's content. Sometimes you come across conditions in certain places which makes the use of a blow torch, when soldering splices in electric wiring, hazardous or prohibitive on account of the nature of the material being processed causing dust to float in the air or fumes from paints, lacquers, benzine, turpentine, etc., being present.

To avoid using a blow torch for work under such conditions, a small babbitt ladle with a holding capacity of not over 1 lb. will be found very convenient. The solder can be melted in some other place, where it is safe to do so, and carried to where it is to be used. If several joints are to be soldered, they can be prepared first and soldered one at a time by dipping in the ladle. Quite a saving is made in foot work and time is saved besides eliminating the explosion hazard.

Superior, Wis. FRED RUTLEDGE.

How the Demand Charge May Be Reduced

THE DEMAND CHARGE, when power is purchased from an outside source, is often overlooked when a means of cutting down costs is under consideration. The demand charge is not well understood by many executives and there is still less knowledge regarding it among the actual operators of the plant machinery. There are various kinds of demand charge, usually with a minimum based in some way on the connected load. The charge may be based on so much a kilowatt or by the horsepower. The demand is always read on the meter in kilowatts. The demand is based on the amount of power used over a short period of time, 15 min. or more. That is, the demand meter makes an accumulative reading of the power used in the interval, then the pointer drops back to zero and the whole cycle starts over again.

To show how it works, suppose a customer has five different departments, each having a demand of 120 kw. That is, with one department running alone, the demand meter would register 120 kw. on the average. Naturally this figure in actual practice would show considerable variation from the mean value selected. Now, suppose again that only two of the five departments are running, the demand would then average about 240 kw. A charge of say $1.50 a kilowatt would make the demand charge of $360. This would be the charge should only the two departments operate during the entire billing period, one month. Now if a third department should be operated for only 15 min., the demand would come up to 360 kw., yet the actual kilowatts consumed and registered on the power meter would be one-fourth of 120 or 30 kw-hr. With a consumption of only 30 kw-hr. the demand charge has been boosted from 240 to 360, making a total charge of $540, which means $180 more added to the bill. Disregarding the actual cost of the power used according to the total rate, this would mean that the cost per kilowatt hour for the 30 used would be 30 divided into 180 or $6.00 a kilowatt.

Now it is not often that a department would be started for just a 15-min. period, but even if it were to be run for a 7-hr. day the extra demand charge of $180 would make it rather expensive power. Seven times 120 would mean a power consumption of 840 kw-hr. and this divided into 180 would give a rate of $0.214. As more and more power is used the demand charge per kilowatt used would go down and eventually the rate would come out in a satisfactory manner. Yet in many cases due to ignorance of the fact that a demand charge is in effect someone will start up a whole department for just a short job that might have been taken care of by operating overtime on one of the other departments.

The case just cited is unusual but I have run across several cases where it has actually happened. In order to reduce the demand charge to a reasonable figure it is often possible so to arrange the schedule of work that two large units are not on at the same time. In the process industries especially, it is often possible to make some slight change in the operation so that the demand can be reduced. For instance in one case it had been customary to grind certain materials during the daytime. The flow of material through the machine was almost entirely automatic yet it needed someone around. It was also necessary to have someone on the shift during the night hours. By the addition of a slightly larger bin which would care for all the material used during the day time it was possible to shift this grinding operation to the night shift. By doing this the demand was reduced by about 65 kw., a worthwhile saving.

There are many cases, and each one requires a study of the actual conditions, where by a rearrangement of the operating time can be made without creating any hardship on the operators or changing the efficiency of the plant. Pumps, especially when they do not need to operate continuously, will be found to prove a source of savings. A larger supply tank may make is possible to entirely cut out pump operation during the working hours. Fire pumps should be run occasionally during the month to see that everything is in first class working condition. An electrically driven pump used for emergency only, had a 100-hp. motor directly connected to it. The demand in kilowatts was about 70. If this pump was tested out dur-

ing the working day this would be added to the regular demand charge and would be rather expensive if, say, it were run only a couple of hours a month. By testing it out when the main load is not on, only the regular kilowatt-hour charge would be made for the power consumed.

Another way in which the demand may be reduced is by the installation of an auxiliary power plant which may be put in operation during the peak load period. In some cases a throw-over switch is used to connect the auxiliary power and in other cases the generator may be synchronized in with the power supply. It is not always feasible to invest in a power plant but there are often cases when it does pay, especially if the peak is of short duration each day, say from two to four hours and of considerable magnitude. The question of auxiliary power is one for thorough study and should not be gone into until the full facts are known.

The demand charge may be reduced by making a thorough study of the plant and the loads taken by the various motors. By re-scheduling the operation a saving may be had in some cases. In other cases it is only necessary to explain to the operators the effect of running extra machines when it can be arranged so that the power peak is not raised. The process industries are especially susceptible to changes in operating schedule when a real saving can be made. A plant does not necessarily have to be of enormous size to effect such saving and in fact in proportion the savings are greater in the smaller plant. Some plants have gone to considerable expense in keeping track of the demand and have had special meters installed which give a signal when the demand is getting above the normal. While this idea is all right, equal results can be obtained by the coöperation of the machine operators and a scheduling of operations so that the heaviest loads are not all on at the same time.

Sayreville, N. J. K. B. HUMPHREY.

Plant Inspections By Outside Engineers

IN AN eastern power system it is frequently the practice to invite one or more outside engineers to accompany the representatives of the local property staff on their trips to generating plants and substations. These outsiders may be consultants of the company, but whether they are retained on a monetary basis or not, the management believes that the trained eye of a technical visitor is likely to observe conditions of equipment or of operation to which local men have become more or less immune through familiarity or oversight. That this is true will be vouched for by most engineers who have visited installations with open minds and a desire to learn what to avoid as well as what to follow in local practices and arrangement of plant facilities.

Friendly criticism on an inspection trip is stimulated by the atmosphere of inviting suggestions as to betterments. On other occasions many visitors hesitate to comment adversely on what they observe and probably are not on the lookout for "ragged edges" to the extent prevailing in the company of others bent on inspection routine. A sense of hospitality holds back many such comments, although open-minded engineers invite them, if not as direct criticism in some cases, in the form of questions as to why certain practices prevail. To enlist the regular consultant of a power system as a member of an annual or semi-annual inspection party is a good investment, both from the viewpoint of better acquaintance with personnel and up-to-date knowledge of the system, plant layouts and operating problems.

Cambridge, Mass. H. S. KNOWLTON.

Unit vs. Group Drive

WHOEVER unreservedly says that group drive is better and more economical than unit drive makes an unwise assertion; in the same manner a statement made without any reservation claiming superiority for the unit drive is equally wrong. There can be no just decision in any particular case until all of the factors have been studied and figured in. There are places where group drive will show far greater economy than the unit drive, and there are places where the unit drive will be by far the better.

In one particular, I believe, unit drive has a distinct advantage, and that is in the case of a directly-mounted motor applied to the cutter shaft or spindle of such woodworking machines as saws, shapers and molders. This is particularly true in cases where it is seen to be an advantage to tilt a saw arbor, a molder head or a shaper spindle. There are a few such machines which have been fitted with better adjustment facilities because of the added advantage of the directly-mounted motor. The motor and the cutter spindle are one unit, and they tilt as such. In the case of the modern variety saw, for instance, the saw blade is tilted, where in the old days the table was tilted. Now, the table remains level while beveled cuts, etc., are being made.

Very powerful and positive unit drives can be arranged for slower machines a great many times by installing worm-gear drives from individual motors. This makes a very compact arrangement as well. Where these features are of particular value, they may possibly outweigh plain dollars-and-cents economy which could be procured through the group drive.

Peoria, Ill. JOHN E. HYLER.

Old "B" Eliminator Chokes Make Good Bell Transformers

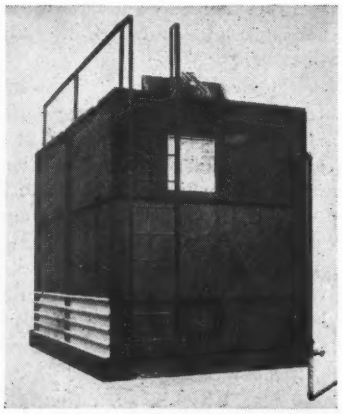
THE SIXTH paragraph of the article in the December Reader's Conference, headed as above reads: "Count the number of turns on the top layer, in the 10 for good measure)." This should read: "Count the number of turns on the top layer, in the case cited it is 125, then $1150/125 = 9.2$ layers (allow 10 for good measure)."

STOCKS of domestic and foreign crude petroleum at the close of the week ending January 11, 1936, totaled 297,783,000 barrels, according to data compiled by the Bureau of Mines. Compared with the data of the previous week, this total represents a decrease of 716,000 barrels, comprising decreases of 628,000 and 88,000 barrels in stocks of domestic and foreign crude, respectively.

New Equipment

Cooling Towers

BINKS MANUFACTURING Company, 3114 Carroll Ave., Chicago, Ill., has anounced a new line of induced draft cooling towers with a cooling capacity ranging from 5 to 200 g.p.m. These new type towers are recommended for refrigeration plants having from 1 to 50 t. refrigeration capacity and for all industrial plants using Diesel engines and other internal combustion engines which need jacket water cooling for their effective operation.



Depending upon tower size and capacity, one or more fans are used, the fans being driven by individual splash and weather-proof motors at speeds of approximately 450 r.p.m. All towers of the type "K" series are constructed of heavy steel frame surrounded by a sectional copper-bearing galvanized steel housing asphalted and aluminum painted inside and out before shipment.

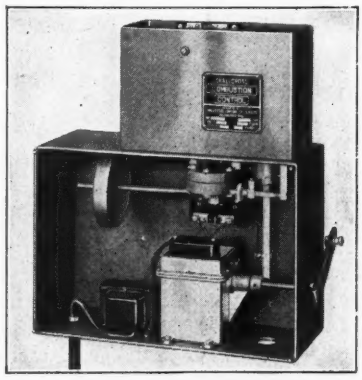
Johns-Manville's Brake Lining

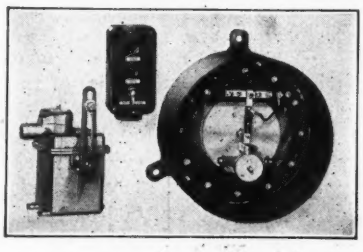
JOHNS-MANVILLE has just announced a new woven and compressed brake lining known as style No. 900. This product has been introduced after several years of experimentation and development in the J-M laboratory and in the field. It has had test use on gas and Diesel friction power shovels and other excavating machinery for the past year with outstanding success. Now it is being offered for general use on all kinds of heavy industrial equipment.

Woven and compressed lining is unique in that it incorporates the fundamental structure of the solid woven lining with the high wearing qualities of the compressed styles. The outstanding feature of woven and compressed lining, as compared with the folded and compressed styles, is that it cannot ply separate in high-temperature service. It has the same low rate of wear and efficient friction characteristics as the folded and compressed type. It is also flexible, readily formed and is adaptable to various speed requirements. In addition, it is mechanically strong and will withstand severe shock-loading.

Combustion Control

SHALLCROSS CONTROLS, INC., Milwaukee, Wis., recently announced two new combustion controls, Type MC and Type L 125. Type MC is a steam pressure controller of the electrical type operated from a.c. and designed to maintain uniform steam pressure and the correct air-fuel ratio. It is adaptable to all types of fuel, any type of stoker and any number, size or type of boiler. Type L 125 is a draft controller, also of the electrical type, designed to maintain a constant furnace draft by adjustment of the stack damper. It is built in four sizes, Types A, B, C and D, ranging from a 44 lb. pull on a 5 in. crank to 600 lb. on a 10 in. crank. Types A and B are built for a.c. only; types C and D for either a.c. or d.c. The complete control consists of a sensitive diaphragm type switch, a damper motor and a manual control station switch.





Plugs and Receptacles

FOR EXTRA HEAVY duty, where conventional plugs and receptacles are not well suited, this "JUMBO-TYPE" has many applications. It is made by the Delta-Star Electric Company, Chicago, Illinois.

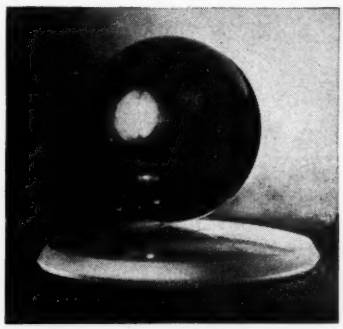
Construction is robust and simple; the various elements being held in position by simply screwing together heavy metal outer sections. Receptacles are tapped for 2 in. conduit and for smaller sizes a reducing bushing is used. Two, three and four pole combinations are made.

American Optical Lens

A NEW GOGGLE LENS, having far greater impact resistance than any lens previously used in standard eye-protection equipment, is now being offered by American Optical Company. The new lens, called the 6-Curve Super Armorplate, gets its extra strength from its high curvature, according to a statement issued by the manufacturer. An indication of its superior impact re-

sistance is provided in the account of tests used to determine its strength.

A one-inch solid steel ball was dropped on the lens from a height of ten feet. The unretouched, stop-motion photograph reproduced here —taken by Professor H. E. Edgerton of Massachusetts Institute of Technology shows how the camera caught the action. This photograph, said to be the first ever taken of



an impact goggle lens at the moment of impact, required an exposure of only 1/100,000 of a second. The standard test for goggle lenses specifies a 5/8-in. steel ball dropped from a height of 39 inches. A height of three times the government standard, and a weight of four times the standard was used in testing the new 6-Curve Lens: a blow having twelve times the energy of the standard test.

Besides its advantages in resisting impact hazards, the 6-Curve Lens is declared to be more effective in deflecting glancing blows, because of its higher curvature; and it is also stated that the curvature permits a closer fitting to the face without interfering with the eyelashes. In the event of fracture by an irresistible blow, tests indicate that the curvature tends to push the fragments out and away from the eye.

The new 6-Curve Lenses are optional equipment in American Optical goggles.

Seamless Tubes

THE BABCOCK & WILCOX Tube Co., Beaver Falls, Pa., announces the commercial production of seamless tubes and pipe of a highly alloyed steel containing 25 per cent chromium and 20 per cent nickel. These products are available hot-finished in sizes up to 6 in. outside diameter and cold-drawn in smaller sizes. This new alloy is being marketed under the trade name B&W Croloy 25-20.

This alloy has a high degree of oxidation resistance and is suitable for continuous operation at temperatures up to approximately 2100 deg. F. It is a ductile material possessing greater creep strength and resistance to oxidation at high temperatures than is possessed by alloys now commercially available in the form of seamless tubing. Its properties are such that the alloy will undoubtedly find a field of usefulness in high-temperature cracking, polymerization and other refinery operations, as well as for high-temperature equipment such as recuperators, thermocouple protection tubes, valves, and heat-resistant tubular members.

This alloy has been available for high-temperature application in sheet, plate, rods, and castings, but has not, heretofore, been made available in seamless tube form except through a tedious forging and boring process.

Air-Operated Indicator-Controller

FOR PRESSURE AND temperature control applications not requiring a record of the factor under control, Bailey Meter Company, Cleveland, Ohio, has developed an Indicator-Controller which may operate either a diaphragm motor valve or an air-operated control drive. This controller is housed in a 13 in. diameter round casing and may be mounted either flush on a panel or on a wall or column.

It incorporates an indicating pointer and scale graduated to measure the factor under control. A second pointer indicates the standard for which the controller is set so that the two pointers coincide when the controller is in operation. The standard setting may be changed to any desired point by turning a knurled knob located under the indicating dial. An adjustment is also provided whereby the sensitivity or "control range" may be varied from 1 percent to 1000 percent of the measuring range.

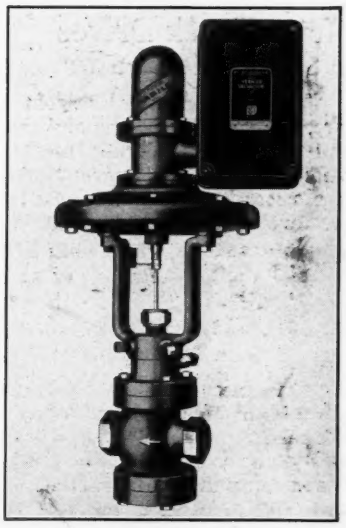
Inside the casing, a Bourdon tube type pressure spring actuates both the indicating pointer and a free floating air pilot valve. Inlet and outlet air pressures to this pilot are indicated by small gages on either side of the main indicating dial and connections for air supply and control pressure are made through the rear of the casing with 1/4 in. O.D. copper tubing.

Keeler Boiler

NOTICE of the new type CP water tube boiler being offered by E. Keeler Co., Williamsport, Pa., was made on page 72 of the January issue. This notice said that the boilers are made in sizes up to 250 hp. It should have read: "Units up to 250 hp. can be shipped made up; sizes in excess of 250 hp. are shipped knocked down and assembled in the field."

Vernier Valvactor

VERNIER VALVACTOR is a new accessory for air-operated control valves developed by the Foxboro Co., Foxboro, Mass., to eliminate valve sticking and to assure hair-line valve positioning. It is the latest addition to the line of control instruments manufactured by the



Foxboro Co. This device enables throttling type air-operated control instruments to make small gradual adjustments of the control valve position regardless of friction or hysteresis. It is claimed that the air from the control instrument need change as little as 1/2 in. of water to cause a corrective positioning of the valve and force the stem to take a position within 0.001 in. of the previous one.

In the great majority of installations control valves will respond proportionately to small changes in air pressure without this device. The Vernier Valvactor, however, guarantees exact valve response where the valve stem packing must be very tight to prevent leakage; where the fluids are viscous or contain solids; and friction is otherwise unavoidable or wherever there is danger of valve friction devel-

oping. The use of air relay in the Vernier Valvactor assures fast and positive operation because an ample supply of air is always available.

Mounted in a cast aluminum case, the unit is completely weatherproof, and may be exposed to the elements. The case is also available in gas-tight construction properly vented so that the Vernier Valvactor may also be operated indoors on gas supply with the vent piped to a safe spilling point.

The Vernier Valvactor can be attached directly to the spring housing of all sizes of Stabilflo valves. For needle valves and valves without the Stabilflo type of motor, the Vernier Valvactor is mounted on the side of the motor supports. It can be installed very easily to valves in the field, with but little interruption to service.

Motor Truck Drives Welding Generator

JOB WELDERS, pipe line contractors, steel erectors, repair shops and other arc welding users to whom portable welding equipment is a necessity, can now install an arc welding generator on any standard 1½ ton truck and drive

the welder direct from the truck motor. This is made possible by a power take-off developed by The Hercules Steel Products Company, Galion, Ohio, in conjunction with The Lincoln Electric Company, Cleveland, Ohio.

The accompanying illustration shows a truck equipped with one of the units driving a Lincoln "Shield-Arc" welder.

This power take-off which makes a truck a power plant as well as a means of transportation, is made in various models to operate as a direct drive or from the side. The unit is adaptable to all makes and models of trucks. It does not affect the road speed or power of the truck, since it simply replaces a portion of the truck's drive shaft.

Power supplied by any leading make of 1½ ton truck is sufficient to drive either a 200 amp. or a 300 amp. welding generator. Power take-off can be controlled from the driver's seat by a single lever. While welding, the speed of the truck motor is controlled by a fly-ball type mechanical governor.

Made of chrome-nickel alloy steel, this power take-off weighs 100 lb. fully installed. All bearings are anti-friction ball and roller type. The unit is guaranteed to transmit 120 br. hp. at 2800 r.p.m., 220 ft. lb. torque.

Pneumatic Hose

A NEW AIR HOSE, designed especially to overcome the deteriorating effects of hot oil from air compressors, is announced by The Republic Rubber Company, Youngstown, Ohio. The tube is made from a compound similar to that used in oil conducting hose and can actually be saturated with oil for long periods of time without affecting its serviceability.

In addition, the hose has great resistance to heat, high pressures, abrasion, the cutting effect of sharp rock and exposure to sun and weather. It is recommended for mines, quarries, rock industries, road work, contracting and general industrial use where service is exceptionally severe.

Great strength has been obtained, without impairing flexibility, by constructing the plies from a specially twisted cord which is thoroughly impregnated with a new tenacious rubber compound. This also increases the bursting and working pressures, and results in greater resistance to shock and abuse.

All construction details of the new hose have been so balanced and engineered as to result in strength without excess bulk or useless weight. Hose costs can be considerably reduced because of longer life and fewer replacements.

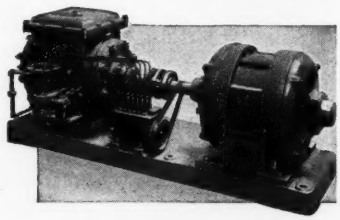
Draft Controller

A COMPLETE self-contained furnace draft controller requiring only a draft connection to the furnace and a supply of compressed air at approximately 35 lb. pressure has been developed by Bailey Meter Company, Cleveland, Ohio.

This controller accurately measures furnace draft with a large sensitive diaphragm, the movement of which actuates an air pilot valve admitting pressure to one end or the other of a drive cylinder until the damper position or fan speed has been changed sufficiently to restore furnace draft to the desired value.

Ro-Twin Compressor

ALLIS-CHALMERS MFG. Co. announces the Ro-Twin a new line of two-stage sliding vane rotary air compressors for pressures up to 100 lb. ga. in which both stages as well



as the inter-cooler, are contained in a single casing. Compared with the usual design of two-stage rotary having two separate cylinders, it offers the advantages of reduced length and floor space, less weight, but one stuffing box and one coupling, no external air piping between stages to keep tight and a simpler lubrication system. The air delivery is free from pulsations.

Worm Gear Reducers

ANNOUNCEMENT is made by Link-Belt Co., Philadelphia, Pa., that it has developed and is now in production on a new line of cut-tooth worm gear speed reducers of

simple, compact, accessible construction, offering great flexibility of driving arrangement.

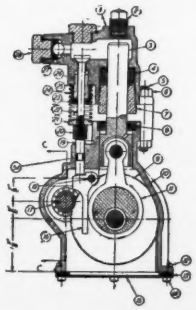
The new reducers are available in a wide range of ratios and capacities, with single or double reduction, and in horizontal and vertical

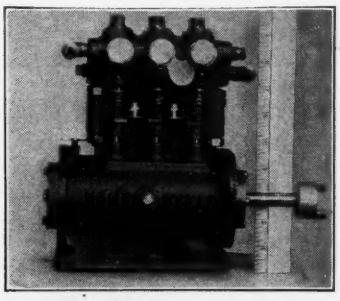
types; all provided with precision tapered roller bearings and automatic lubrication within dust-proof gray iron housings.

Homestead Miniature Triplex Pump

To HANDLE fluids at a relatively high pressure and at the same time in small quantities a miniature triplex plunger reciprocating pump has been developed by the Homestead Valve Manufacturing Co. of Coraopolis, Penn.

Depending upon the speed of the pump the capacity may be varied from about 15 to 120 gal.p.hr. The power required by the pump is small, such that a ¼ hp. electric motor will operate the pump at 60 gal.p.hr. capacity and 200 lb. pressure. It is a single acting plunger type having three cylinders of ¾ in. bore and ⅝ in. stroke with the plungers attached to cross-head guides which are driven by con-



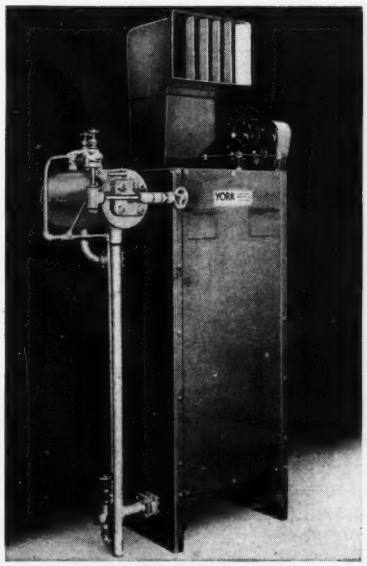


necting rods from the crank shaft. The monel metal inlet valves are of the poppet types, positively actuated through a cam and tappet mechanism and the outlet check valves are of the ball type with adjustable limited lift for high-speed operation. The gears, crank shaft, connecting rods and cross-heads are entirely enclosed in a crank case with splash lubrication. The crank case is made of semi-steel. The cylinder head is made of a corrosion-resisting iron alloy and is removable from the crank case effecting economical maintenance.

This pump has a wide application because of the low horsepower required (1/6 to ½), the wide range of pressure (0 to 500 lb.), and the positive displacement feature (high volumetric efficiency). Pure water, water containing various percentages of alkaline compounds, fuel oils, mineral oils and various chemicals are readily handled by this pump. It is adaptable to a great variety of uses such as boiler feed, boiler compound injection, condensate returns, small hydraulic presses, fuel oil pumps for oil burners, pumping of chemicals, air conditioning apparatus and control appartaus.

Air Conditioners

NEW INDUSTRIAL air conditioner units, designed to meet a wide range of industrial air-cooling requirements has been announced by



the York Ice Machinery Corp., York, Pa. The new models, designated as FB-500, FB-800, FB-1400 and FB-2000, can be installed in any industrial plant, with or without distributing ducts. The new conditioners are built in a sufficiently wide range of sizes to meet every requirement of capacity and temperature and permits their use where storage or floor space is limited.

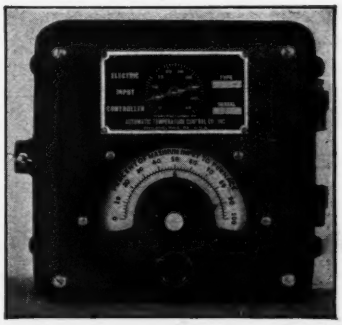
Fans are of the quiet operating multiblade, double inlet type, providing low outlet velocities, with V-belt drive to insure flexibility of speeds and allowing for the ready adjustment of air volume to meet specific industrial requirements. Cooling and dehumidifying surfaces are of ¾ in. full weight pipe, bent from single lengths and fabricated into all-welded units. Automatic control of room temperature at any desired level is accomplished through thermostatic regulation of the refrigerating operation, or where the units are connected with a central refrigerating system, by controlling the flow of the refrigerating element.

Input Controller

FOR USE in connection with furnaces, ovens, platens and other electrically heated industrial units. The Automatic Temperature Control Co., Philadelphia, Pa., has placed on the market a new current input controller. Advantages claimed for this new controller are more flexible adjustment, greater accuracy in setting and finer regulation than previous models. Several models are available.

Model M is designed to prevent a constant load from rising in temperature beyond a desired and readily adjusted setting.

Model MT exercises the same control of overshooting as Model M but, in addition, is provided with



built-in time control which brings input-control into action after an adjustable period.

Models F and FL are designed for control where loads are variable. Both models adjust automatically to changes in demand, with Model F serving installations having but slight lag in furnace response and Model FL serving where lag is greater.

Turning of an external knob adjusts the position of a 10-amp. snap-switch in relation to a rotating cam. This one adjustment determines the period during each cam-rotation during which current will be flowing to the heating unit. For capacities greater than 10-amp. at 110 v.a.c. (see table below), mercury contact tubes rated up to 90 amp. 110 v.a.c., are available. The mercury tubes are solenoid operated with spring cushioning to

avoid undue mercury agitation. The entire unit is housed in a hinged, gasketed, aluminum case, 8¼ in. in height, 9¾ in. in width, 4¾ in. in depth.

Gear Motor

WAGNER ELECTRIC CORP., St. Louis, Mo., has developed fractional-horsepower gear-motors that are suitable for direct connection to stokers, agitators, conveyors, low-speed pumps, mixers, or any application requiring special speeds. They are inexpensive, highly efficient and compact.

These gear-motors are available in single-reduction and double-reduction types, with right-angle shaft drive; and in single-reduction, double-reduction, and triple-reduction types with parallel shaft drive. They are available for delivering power at speeds as low as 6-r.p.m.

Welding Conference

ON FEBRUARY 13 and 14 the Mechanical Engineering Department of the Texas Technological College, Lubbock, Texas, will hold its second annual welding conference to which all persons interested in welding are invited. There is no charge for the conference and preparations are being made for an attendance of 500 people. Inquiries regarding the conference should be addressed to J. C. Hardgrave at the college.

On the program are the following papers which are of interest to engineers in power plants:

Multiple-Flame Welding, by H. O. Green, Linde Air Products Co.

Economy in Quality Welding Through Personal Training, by L. C. Monroe.

Identification of Metals to be Welded, author to be supplied.

Some Recent Developments in Silver Solder and Brazing, by A. W. Swift, Handy & Harman Co.

Hard Surfacing, by Don Llewellyn, Air Reduction Sales Corp.

Welding in Plant Rehabilitation, by Robert Notvest, J. D. Adams Co., Inc.

Seam and Spot Welding, by R. V. Van Kirk.

Eskil Berg

ESKIL BERG, prominent retired engineer of the General Electric Company and one-time associate of the late Dr. Charles P. Steinmetz, died at his residence at Ballston Lake, New York, on January 5.

He was born in Sweden and immediately after graduation from the Chalmers Institute of Technology at Gothenburg, Sweden, came to this country and became associated with the General Electric Company. For many years, he worked with Dr. Steinmetz, and after Dr. Steinmetz' office had been discontinued, Mr. Berg became an associate of W. L. R. Emmet and was connected with work on the steam turbine, on the development of electric ship propulsion, and on the mercury turbine.

Dean Potter Heads A. E. C.

DR. A. A. POTTER, Dean of Schools of Engineering, Purdue University, has been chosen as President of American Engineering Council for 1936 and 37, to succeed J. F. Coleman, of New Orleans. Dean Potter took office at the annual meeting of the Council held January 9, 10 and 11 when representatives of national, state, and local engineering societies convened in Washington.

Dean Potter is a past president of the American Society of Mechanical Engineers, the Society for the Promotion of Engineering Education, the Indiana Engineering Society, and the Kansas Engineering Society, which are member bodies of the national Council. He was born in Vilna, Russia, 1882; graduated from the Massachusetts Institute of Technology; and was awarded a doctor's degree in engineering at Kansas State College where he later became Dean of Engineering. Since 1920, he has served as Dean of the Schools of Engineering, director of the engineering experiment station, and professor of power engineering at Purdue.

He is author of text books, including "Farm Motors," "Elements of Steam and Gas Power," and "Engineering Thermodynamics" as well as of over 300 articles and papers published in engineering and education magazines. His record includes prominent consulting work with the government and with private firms.

Fred R. Low

FOLLOWING critical illness for several years, Fred R. Low, Editor Emeritus of "Power," died at his home in Passaic, N. J., on January 22 at the age of 75 years.

Mr. Low gained high recognition in journalism and engineering through his position as editor of "Power" for 42 yr. from which position he retired in 1930. His formal schooling stopped at the age of 14 yr. but by self education he became an international authority on power equipment and its operation, and in 1924 was conferred with the degree of Honorary Doctor of Engineering by Rensselaer Polytechnic Institute. He was Past President of the American Society of Mechanical Engineers, former Mayor of Passaic, honorary member of the British Institute of Mechanical Engineers, honorary member of the National Association of Practical Refrigerating Engineers

and of the National Board of Boiler and Pressure Vessel Inspectors, a member of the National Ass'n. of Power Engineers, the Vereines Deutscher Ingenieure, the Newcomen Society and many engineer's clubs and fraternal societies.

Mr. Low was born April 3, 1860, at Chelsea, Mass., became telegraph clerk and stenographer in 1874, court and commercial stenographer in 1878, entered editorial work with the Journal of Commerce, Boston, in 1880 where he conducted a department devoted to the technical problems of textile-mill power plants. This position he left in 1888 to become the editor of "Power" to which journal he devoted the remainder of his life's work. He is survived by his wife, Adeline Giles Low, a sister, four children, fourteen grandchildren and two great grandchildren.

News From the Field

ANNOUNCEMENT has been made by The International Nickel Co., Inc., New York, that Thomas N. Armstrong, Jr., has been appointed to the technical staff and will handle the steel castings development for the company, with offices in New York City. Mr. Armstrong has been associate metallurgist at the Norfolk Navy Yards and prior to that spent several years with the Andrews Steel Co. in open hearth furnace work.

ON JUNE 5 to 11 a short course in coal utilization will be conducted at the University of Illinois, Urbana, Ill. The details of the program have not as yet been announced but will be completed about April 15. A. C. Callen, head of the department of Mining and Metallurgical Engineering, is arranging the course and is in position to answer questions in regard to it.

WESTINGHOUSE ELECTRIC & MFG. CO., East Pittsburgh, Pa., announces the appointment of R. R. Davis, formerly assistant manager of the advertising department to succeed Ralph Leavenworth, who has resigned as manager as of January 1, 1936. Mr. Leavenworth will join Fuller & Smith & Ross, Cleveland, advertising agency which handles the Westinghouse account.

ELLIOTT CO., Jeannette, Pa., announces that on January 1, 1936, the Liberty Mfg. Co. of Jeannette, Pa., and the Lagonda Mfg. Co., Springfield, Ohio, which have been operating as separate subsidiary companies of the Elliott Co., were merged with the Elliott Co. into one organization. The manufacture of both the Liberty and Lagonda tube cleaners continues exactly as before but under the name Elliott Co. Both Liberty and Lagonda companies started business more than 35 yr. ago, pioneering in the field of tube cleaners ever since they were organized. In 1916 the Lagonda plant was taken over by the Elliott Co. while the Liberty Mfg. Co. has always been a department of the Elliott Co. It is reported that the consolidation is in the interests of simplification within the organization.

THE BABCOCK & WILCOX TUBE CO., Beaver Falls, Pa., announce the appointment of the Markham Supply Co., 310 South Michigan Avenue, Chicago, Illinois, as their general Railway Sales Representatives for the Chicago, St. Louis, Kansas City, Omaha, and Twin Cities territory. Lloyd H. Wells, formerly railway sales representative of The Babcock & Wilcox Tube Co., will continue in the same capacity with the Markham Supply Co., in the above mentioned territory.

PENNSYLVANIA PUMP & COMPRESSOR CO. announces that the Consulting Engineering Co., No. 1 Terminal Office Bldg., Carson St., Pittsburgh, Pa., has been appointed as representative in the Pittsburgh district. The management of the Consulting Engineering Co. consists of J. F. Tutein and T. G. McCann.

J. E. N. HUME, assistant manager of the General Electric Company's industrial department, has been appointed manager of the department, succeeding the late W. W. Miller, it was announced December 26 by E. O. Shreve, vice-president of the company. Mr. Hume had been assistant manager for the previous six years and in that capacity was responsible for general sales direction, policies, prices, consignments, and similar activities of the department.

GEORGE H. REID has been appointed industrial department manager of the General Electric Company's New York district, succeeding Fred S. Hartman who retired at the close of the year, according to a recent announcement made by H. H. Barnes, Jr., commercial vice-president of the company. The appointment became effective January 1, 1936. Mr. Hartman's services, Mr. Barnes stated, will still be available to the company in an advisory capacity.

BURNS AND ROE, INC., which specializes in mechanical and electrical design of power plant equipment for industrial and public utility plants, has recently moved its offices to the Woolworth Building, 233 Broadway, New York City. Robert H. Wyld, who was for many years connected with the Foster Wheeler Corp., has recently joined this firm.

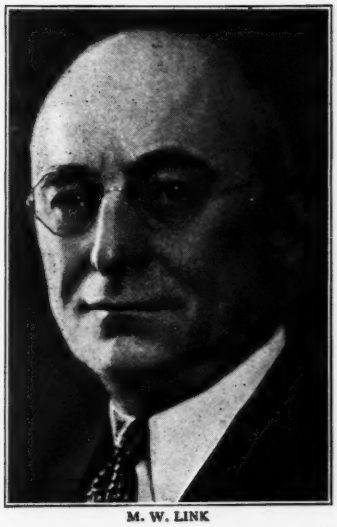
REPUBLIC STEEL CORP. moved its general offices on January 25 from Youngstown, Ohio, to Cleveland, Ohio, where the offices will occupy four floors in the former Medical Arts Bldg., recently named the Republic Bldg. This move consolidates the general offices which have been located in Youngstown, the executive and Cleveland district sales offices formerly in the Union Trust Bldg., Cleveland, and the advertising department, Massillon, Ohio. The Newton Steel Co. will also have its sales offices located in the Republic Bldg.

ANNOUNCEMENT has been made that the 1936 National Metal Congress and Exposition will be held in Cleveland's Public Auditorium October 19th to 23rd, inclusive. Five technical societies coöperate to stage this annual event. They are the American Welding Society, the Wire Association, the Institute of Metals and Iron and Steel divisions of the American Institute of Mining and Metallurgical Engineers, and the American Society for Metals. The annual conventions of these Societies will be held at this time.

DUE TO the importance and volume of research and development work which is being carried on by Crane Co., Chicago, Ill., a new Division of Research and Development has been established by the company. This division will engage constant full time effort of a group of technical specialists entirely divorced from routine production. They will devote their entire time to a study of the requirements of the trade; with freedom to pursue the research designing and experimental work necessary to improve existing products, and to develop original designs and materials for new products. The research and development work formerly handled by various departments and subsidiaries will be expanded and centralized in the new division.

The character of work covered by the new division is indicated by some of the units which it comprises. There will be one for field research, separate units for research and development on industrial products, plumbing products, and heating products. Separate laboratories for research testing and metallurgical research. One unit will be devoted to standardization programs, and another to patents and inventions.

M. W. Link will head the new division, with the title of Director of Research and Development. His assistant will be B. A. Parks. Specialized work will be under the charge of A. M. Houser, Engineer of Standardization; C. A. Olson, Research Engineer, industrial and heating products; R. H. Zinkil, Research Engineer, plumbing products; J. P. Magos, Testing Engineer, research testing laboratories; and J. O. Lange, Engineer of Patents.



M. W. LINK

Announcement is also made of the creation of a new Product Engineering Department at the Chicago Works under the jurisdiction of the Vice-President of Manufacture. The initial personnel will be C. A. Dopp, Product Engineer; A. M. Houser, Jr., Assistant Product Engineer, and C. F. G. Neuhaus, Drafting Supervisor.

There will be close association between the Division of Research and Development and the Product Engineering Department, so that the latter may place in proper production the products or improvements in existing products developed by the Division of Research and Development.

ORDERS RECEIVED by the General Electric Co. during the year 1935 amounted to $217,361,587, compared with $183,660,303 during 1934, an increase of 18 per cent. Orders for the quarter ended December 31 amounted to $58,417,822, compared with $51,046,760 for the last quarter of 1934, an increase of 14 per cent. Sales billed and earnings for the year 1935 are not yet available. A complete annual report will be issued in March.

BARTLETT HAYWARD CO., Baltimore, Maryland, announces the following changes in the officials: Chester F. Hockley, who has been President of The Bartlett Hayward Company since 1931, has retired to become President of the newly reorganized Davison Chemical Corp. He will, however, continue as a Director of The Bartlett Hayward Co. Walter F. Perkins, formerly Vice President and General Manager, has been elected President. Geo. E. Probest, Jr., formerly Secretary and Treasurer, has been elected Vice President and Treasurer. Herman H. Vordemberge, formerly Assistant Secretary and Assistant Treasurer, has been elected Secretary and Assistant Treasurer.

ANNOUNCEMENT has been made by the Riley Stoker Corp., Worcester, Mass., that L. E. Griffith has been appointed vice president and general manager of the corporation. Mr. Griffith is a graduate of Lafayette University with extensive experience and broad knowledge of the power industry, having had connection with such firms as Thompson Starrett Co., General Metal

Products Co., Pittsburgh Seamless Tube Co., the Babcock & Wilcox Co., coming to the Riley Stoker Corp. at the time the United Machine & Manufacturing Co., of which Mr. Griffith was president and general manager, was purchased by this corporation.

ANNOUNCEMENT was made by the American Society of Heating and Ventilating Engineers that the F. Paul Anderson Gold Medal has been awarded to Dr. Arthur Cutts Willard, President of the University of Ill. for distinguished scientific achievements in the field of heating, ventilating and air conditioning. The Committee on Award honored Dr. Willard for his outstanding work as an engineer, a teacher and an author in the fields of heating, ventilating and air conditioning; for his outstanding service as a consultant on the ventilation of the Holland Tunnel, the United States Capitol and the proposed Chicago Subway; for his outstanding work in research and for the service he rendered to the Society as a member, as an officer and as technical adviser to its Committee on Research.

In accordance with the authority and responsibility placed upon it by the General Conference of Weights and Measures in 1933, the International Committee of Weights and Measures has decided that the actual substitution of the absolute system of electrical units for the international system shall take place on the 1st of January, 1940.

In collaboration with the national physical laboratories, the Committee is actively engaged in establishing the ratios between the international units and the corresponding practical absolute units.

The Committee directs attention to the fact that it is not at all necessary for any existing electrical standard to be altered or modified with a view to making its actual value conform with the new units. For the majority of engineering applications the old values of the international standards will be sufficiently close to the new for no change, even of a numerical nature, to be required. If for any special reason a higher precision is necessary, numerical corrections can always be applied.

The following table gives a provisional list of the ratios of the international units to the corresponding practical absolute units, taken to the fourth decimal place. Since differences affecting the fifth decimal place exist between the standards of the international units held by the various national laboratories and also because all the laboratories which have undertaken determinations of the values of their standards in absolute measure have not yet obtained final results, the Committee does not consider it desirable for the present to seek a higher precision. At the same time it hopes that it will be possible to extend the table of these ratios with a close approximation to the fifth decimal place well before the date fixed for the actual substitution of the practical absolute system for the international system.

TABLE

1 Ampere International	= 0.999 9	Ampere Absolute
1 Coulomb International	= 0.999 9	Coulumb Absolute
1 Ohm International	= 1.000 5	Ohm Absolute
1 Volt International	= 1.000 4	Volt Absolute
1 Henry International	= 1.000 5	Henry Absolute
1 Farad International	= 0.999 5	Farad Absolute
1 Weber International	= 1.000 4	Weber Absolute
1 Watt International	= 1.000 3	Watt Absolute
1 Joule International	= 1.000 3	Joule Absolute

IN THE PROGRAMS of the Midwest Power Engineering Conference to be held in Chicago, April 20-24, engineers of national prominence will appear at the sessions to be held in the Palmer House in the morning and at the International Amphitheatre in the afternoon. The Midwest Engineering and Power Exposition will be held at the Amphitheatre.

Among the Conference sessions already organized are those on power economics, coal, refrigeration and power transmission. One of the papers at the power economics session will be on "Trends in Power Research" by C. F. Hirshfeld of the Detroit Edison Company. The coal session will include such topics as "Use Value," "Equipment," "Simplification," "Fuel Economy" and "Coördination of Controls." Joseph Harrington, Chicago engineer, will present a paper on "Simplification of Coal Sizing."

Insulation and refrigerants will be among the topics at the session on refrigeration. L. S. Morse, York, Pennsylvania, President of the American Society of Refrigeration Engineers, will discuss "Power Used in Air Conditioning."

The fourth session now organized will deal with transmission of power to machinery by means of belts and direct motor drives.

Diesel, internal combustion power, fuel power and fuel burning equipment will be among the features of the Exposition. Aside from the products of leading power appliance manufacturers there will be a number of highly interesting scientific exhibits.

For the Engineer's Library

MECHANICAL WORLD YEAR BOOK, 1936. Published by Emmott & Co., Ltd., 31, King St. West, Manchester, England. Size 4½ by 6½ in., 206 pages (exclusive of catalog section), 49th Edition.

For many years this little handbook has maintained its popularity, being revised and added to from time to time in order to keep it up-to-date. This latest edition includes a new section dealing with the strength of tubes, cylinders and pans subjected to external pressure. This has been added as the result of demand for additional material on industrial process steam work.

HIGH SPEED DIESEL ENGINES. By Arthur W. Judge. Published by D. Van Nostrand Co., Inc., 250 Fourth Ave., New York, N. Y. Size 6 by 9 in., cloth bound, 340 pp. Price $6.

This is the second edition, enlarged by about 100 pp. and revised to include developments of the past two years. As an elementary textbook covering the theory and practice of high speed compression ignition engines, the book is of special interest because of the wide range of coverage which includes automobiles and aircraft types which are bound to be of increased importance in the future. The first edition dealt only with English practice and design but the second edition includes typical Continental and American engines thus broadening the scope considerably and giving the reader a wider view of the field than is available in any other book with which we are familiar. The book is divided into 15 chapters covering various types and phases of designs. One chapter each is devoted to care and maintenance, fuel filters and fuels, the latter having been revised to include an account of cetene values and fuel dopes. In the appendix are given data on the wear of high speed engines and operating experience of the London General Omnibus Co. with engines in bus service.

A.S.T.M. TENTATIVE STANDARDS. Published by the American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa. Size 6 by 9 in., 1591 pp. Price, paper bound, $7; cloth bound, $8.

Tentative Standards are standards in the making, both those that have been passed by the committee and published for the first time to elicit criticism and those that have been published before and revised. Pending final acceptance, these standards are widely used and this volume is complementary to the 1933 Book of Standards. In all, 290 specifications and test methods are included, 75 for the first time and 65 in their latest revised and approved form. Two indices are provided, one under the subject and material, the other in numerical sequence of the serial designation.

Many of these are of importance to the power plant field. For instance, extensive revisions were made in the requirements for carbon steel boiler plates, while electric resistance welded boiler tubes, additional definitions of electrical terms, coal classifications, fuel values, fuel oils, electrical insulation testing and rubber pump valves are some of the other specifications listed.

In fact, Edward Everett Horton might have used it to advantage in his game of 20 Questions on His Night Out. For what service would you use a Class B rubber pump valve? Is the power factor of a dielectric best determined, assuming an equivalent series or an equivalent parallel circuit? Should you buy No. 1, 3 or 6 fuel oil? What is net calorific value? What are the B.t.u. limits of high volatile C bituminous coal? The list might be extended indefinitely and the best part of it all is you don't have to turn to page umpety-ump—the answer is right before you.

JOHN S. SWIFT CO., INC., has recently published the 1936 edition of the Pape-Swift Boiler Reference Book. This edition does not duplicate information in the previous editions but the three now list some 76 heating boiler manufacturers and cover specifications of over 900 models. The price of the book is $1 per copy plus 10 cents for postage. A Master Index covering the three volumes is supplied with each of the new books or may be purchased separately for 15 cents each.

INSTRUMENTS AND COMBUSTION CONTROL of three coöperating companies, the Hays Corp., Michigan City, Ind., Carrick Engineering Co., Michigan City, Ind., and the Cochrane Corp., Philadelphia, Pa., are described in a 12-page booklet, No. 2246, which may be obtained from anyone of the three companies.

BENJAMIN ELECTRIC MFG. CO., Des Plaines, Ill. has issued an attractively illustrated new 28 page bulletin on High Intensity Mercury Vapor Lamp Fixtures. This bulletin gives complete data on the new 400 watt high intensity mercury vapor lamp—how it operates, its color composition and its advantages—for various types of interior and exterior illumination.

It gives complete description, illustrations, dimensions and list prices on Benjamin lighting fixtures for the High Intensity Mercury Vapor Lamp with tables on illumination calculations applying to the various fixtures and outlines a method of designing a general lighting system with these fixtures including design of a combination lighting system consisting of mercury vapor and incandescent lamps.

"NEW INSTRUMENTS FOR MEASURING AND CONTROLLING" is the title of a new 12-page bulletin recently issued by Weston Electrical Instrument Co., Newark, N. J. This bulletin presents a brief descriptive review of its products in clear, non-technical language so as to render it more intelligible to the layman and student engineer.

STRUTHERS DUNN, INC., Philadelphia, has issued a new 28 page catalog describing relays, timing devices, thermostats, pots and ladles, resistors, thermal links, insulators, etc., etc.

THE SUPERHEATER CO., of New York and Chicago, has just issued its catalog 20,001-1 on the Elesco non-sparking tools. These tools will prevent the emission of sparks, with attendant fire or explosion where there are inflammable or explosive gases. Special hardening alloys are incorporated in the cutting tools.

THE AMERICAN DISTRICT STEAM CO., North Tonawanda, N. Y., is distributing copies of its new loose leaf, illustrated Catalog No. 35 with over 130 pages of engineering, dimensional and price data on the complete Adsco line of expansion joints, meters, steam traps, pipe casing, water heaters, vapor heating specialties, pipe fittings and other steam distribution equipment.

PROPERTIES OF TONCAN IRON is the title of a small 12 page folder issued by the Republic Steel Corporation, Massillon, Ohio. It contains condensed, up-to-date information on rust resisting Toncan Copper Molybdenum Iron. Included in it are the complete physical properties and physical constants of this corrosive-resisting alloy iron.

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis., has issued a revised 16 page Bulletin 2188A to include its complete recently extended line of Duro Brace Texsteel Sheaves for stock drives up to 15 hp. The bulletin includes dimension tables of all the sheaves, complete horsepower and center distance tables for all recommended stock speed ratios, as well as price list tables of these 2 to 6 groove sheaves and for various standard lengths of texrope belts.

WESTINGHOUSE ENGINEERS have developed a calculating card known as the Simplograph to assist its salesman in calculation of commercial refrigeration problems. The device makes use of 7 fundamental factors including temperatures, type of fixtures, insulation, service, type of coil and method of cooling desired. From these seven factors it is possible to determine the refrigeration load, type of Westinghouse equipment needed for the installation, size and model of the coil, as well as, the approximate operating costs of the installation.

Performance of 115,000 hp. Turbines Predicted by 1¼ hp. Model

IMPRESSIVE CEREMONIES surrounded the inauguration of a test of a small model of a Boulder Dam turbine recently at the laboratories of the I. P. Morris Division of the Baldwin-Southwark Corporation. In the presence of a group of officials and engineers who had gathered to watch the event, William H. Harman, vice president and general manager of the Baldwin-Southwark Corp. pulled the switch which started this important experiment—the 500th laboratory test in the 108 years of the I. P. Morris Division.

Contracts were recently placed by the U. S. Dept. of the Interior, Bureau of Reclamation, for two hydraulic turbines each to develop 115,000 hp. under a head of 480 ft. at a speed of 180 revolutions per minute.

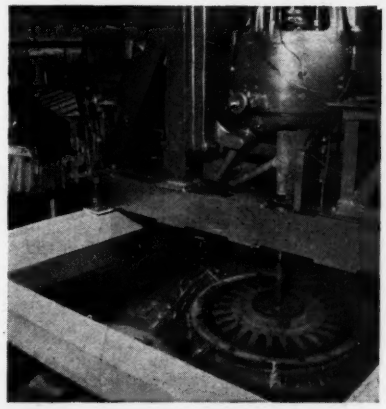


Fig. 1. Group of officials and engineers gathered to watch test of 1¼ hp. model of 115,000 hp. Boulder Dam turbine at the Eddystone plant of the I. P. Morris Division of the Baldwin-Southwark Corp.

Fig. 2. 1¼ hp. model for the 115,000 hp. Boulder Dam turbine at Baldwin-Southwark Plant

Before starting these great turbines, it was decided to build a model unit to be an exact reproduction, but about ⅛ the size of the large units, and to test this model in the laboratory for power outputs and efficiencies under the conditions corresponding to the variations in head expected at Boulder Dam. Changes can readily be made in the model unit to obtain the best possible efficiencies, and from these tests the performance of the large units can be predicted within close limits.

This method of insuring successful operation in the field of hydraulic turbines by building and testing small models was adopted 108 years ago by I. P. Morris, when this company was known as Levi Morris and Co. and this policy was continued when I. P. Morris became a part of Baldwin-Southwark in 1931, at which time a complete hydraulic testing laboratory was built at Eddystone. Tests are made on model units having runners from 16 to 20 in. in diameter in connection with all important installations.

The water is elevated by pumps to the high level tanks in which the model turbine is located, flowing through the turbine and then over the crest of the measuring weir where it is again raised to the pumps. The turbine drives a small generator which acts as an electric break, the output being absorbed by the resistance. The performance of the model turbine as to output and efficiency can readily be stepped up by formulas to obtain the performance of the large turbines under the high head.

The test engineers had wired to the generator an electric cigar lighter and the first power was sufficient to light the cigars of the officials and others who were present.

Power Plant Construction News

Ala., Auburn—Daniel T. Jones, supervising engineer, Alabama Polytechnic Institute, Auburn, is in charge of project to construct a group of about 15 cold storage plants in different parts of State, financing to be carried out through Federal aid. Cost over $180,000.

Ala., Fairfield—Tennessee Coal, Iron & Railroad Co., plans installation of heavy-duty electric power equipment in new addition to steel sheet mill. Entire project will cost about $200,000.

Calif., Chico—Peter Marinoff, care of Lester B. Osborn, secretary, Chamber of Commerce, Chico, plans installation of power equipment in proposed new brewing plant on local site on South Highway. A company will be organized to carry out project. A one-story boiler house will be built. Cost close to $150,000.

Calif., Eureka—Pacific Lumber Co, plans installation of power equipment in connection with proposed rebuilding of Mill B, recently destroyed by fire. Loss estimated close to $50,000, including machinery.

Conn., Bridgeport—Casco Products Corporation, 1333 Railroad Avenue, plans installation of electric power equipment in new addition to automotive products manufacturing plant. Cost about $85,000. Fletcher-Thompson, Inc., Fairfield, Conn., is architect and engineer.

Ga., Waycross—Georgia Power & Light Co., Atlanta, Ga., plans extensions in transmission lines from Waycross to Hoboken and other points in Brantley County, including distributing lines and service facilities for rural electrification. Fund of about $100,000 is being arranged for project.

Ill., La Salle—City Council has plans maturing for new municipal electric light and power plant, including distribution system, and proposes to begin work soon. Fund of $750,000 has been arranged through Federal aid. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

Ill., Pullman—Sherwin-Williams Co., plans installation of electric power equipment in connection with new additions to paint and varnish plant at Pullman, Chicago. Project will be carried out in 1936. Cost over $600,000. Company headquarters are at 101 Prospect Avenue N.W., Cleveland, Ohio.

Ind, East Chicago—Sinclair Oil Refining Co., plans installation of power equipment in connection with proposed extensions and improvements in local oil refining plant. Cost close to $100,000. R. J. Black is superintendent. Company headquarters are at 630 Fifth Avenue. New York, N. Y.

Ind., Muncie—Board of Public Works, City Hall, plans installation of two steam boiler units and accessories, seven electric-operated sump pumps, 11 centrifugal pumps, 150-gal. per min. deep well pump, gas storage tank and other mechanical equipment in new municipal sewage disposal plant. Entire project will cost about $420,800. George G. Gascoigne, Leader Building, Cleveland, Ohio, is consulting engineer.

Kan., Iola—Common Council has plans nearing completion and takes bids soon for extensions and improvements in municipal electric light and power plant, including new steam generating equipment, electrical equipment and electric power lines. Fund of $280,000 has been arranged through Federal aid. Paulette & Wilson, Farmers' Union Building, Salina, Kan., are consulting engineers.

Mass., Salem—H. P. Hood & Sons, Inc., 500 Rutherford Avenue, Charlestown, Boston, Mass., plans installation of electric power equipment in new creamery and milk products plant at Salem, where site has been selected on Bridge Street. Cost close to $100,000.

Minn, Cokato — Minnesota Valley Canning Co., LeSueur, Minn., plans new one-story steam power house at new branch canning plant at Cokato. Entire project will cost over $40,000. Henry C. Gerlach, 414 North Fourth Street, Mankato, Minn., is architect.

Minn., Willmar—State Board of Control, State Office Building, St. Paul, Minn., has plans maturing and soon takes bids on general contract for new addition to power plant at state institution at Willmar, including installation of additional equipment. Cost about $45,000. P. C. Bettenberg, Inc., Metropolitan Life Building, is architect; and G. M. Orr & Co., Baker Building, consulting engineer, both Minneapolis, Minn.

Minn., Winona — Marigold Dairies, Inc., 496 Partridge Street, St. Paul, Minn., plans installation of electric power equipment, mechanical-handling apparatus, etc., in new milk and dairy products plant at Winona. Proposed to begin work soon. Cost about $45,000. Charles A. Berger, Phoenix Building, Minneapolis, Minn., is architect.

Mo., Morehouse — Himmelberger-Harrison Mfg. Co., plans installation of power equipment in connection with proposed rebuilding of portion of lumber mill, recently destroyed by fire. Loss over $200,000. Harry Himmelberger is one of heads of company.

Neb., Omaha—Iten-Barmettler Co., Omaha National Bank Building, Otto H. Barmettler, head, plans installation of power equipment in new biscuit and cracker factory at Thirtieth and Taylor Streets, 270x450 ft. Cost over $150,000. James T. Allen, Brandeis Theater Building, is architect.

N. Y., Perry—Village Council is considering construction of new municipal electric light and power plant, including electrical distribution system. Cost close to $200,000. L. C. Reynolds, Perry, engineer, has been engaged to draw preliminary plans.

N. Y., Saranac Lake—City Council has plans nearing completion for proposed municipal electric power plant, and will proceed with project at early date. A new electrical distribution system will be installed. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

N. C., Enka—American Enka Corporation plans installation of electric power equipment in connection with proposed expansion and improvements at local rayon mill in 1936. Entire program will cost about $500,000. Company headquarters are at 271 Church Street, New York, N. Y.

N. D., Minot—City Council, Jay W. Bliss, city manager, is considering plans for new municipal electric light and power plant, with turbo-generator units, boilers and auxiliary equipment. Cost close to $615,000. Proposed to arrange financing through Federal aid. Lloyd G. Wilhelm is city engineer.

Ohio, Carthage—Penn-Maryland Corporation, a subsidiary of National Distillers Products Corporation, 120 Broadway, New York, N. Y., plans installation of electric power equipment in connection with extensions and improvements in distilling plant at Carthage. Cost close to $500,000. Work will be carried out during 1936.

Ohio, Sandusky—City Commission is planning fund of $1,100,000 for new municipal electric light and power plant. Proposed to arrange financing through Federal aid. Preliminary plans for station are being drawn by Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., consulting engineer.

Ont., Thorold—Ontario Paper Co., has approved plans for new steam-operated electric power plant at paper mill, and will take bids for turbo-generator units and other equipment at early date. Bids for steam power equipment have been asked and orders for certain equipment placed. Proposed to begin work soon. Cost about $1,000,000.

Pa., Carnegie—Wettach Paint & Chemical Co., recently organized by C. D. Wettach, Carnegie, and associates, plans installation of electric power equipment in new local plant. Company has taken over former works of H. L. Dixon Co., with main unit 100x150 ft., and will remodel and equip at early date. Cost over $50,000.

Pa., Lancaster — Lancaster Iron Works, Inc., plans installation of electric power equipment in connection with proposed rebuilding of portion of steel plate and machinery plant, recently destroyed by fire. Loss estimated over $80,000.

Texas, Plainview—City Council has concluded arrangements for Federal grant and loan for $420,000, for new municipal electric light and power plant. Proposed to begin work at early date.

Texas, Texas City—Petrotex Co., plans installation of power equipment in new gasoline refining plant. A boiler house will be built. Battery of steel tanks will be installed. Cost about $350,000. Mid-Continent Engineering Co., First National Bank Building, Dallas, Tex., is consulting engineer.

Texas, Yorktown—City Council plans call for bids early in February for proposed municipal electric light and power plant. Cost about $100,000. Financing has been arranged through Federal aid. Garrett Engineering Co., Houston, Tex., is consulting engineer.

Va., Victoria—Hanover Broad Silk Works, Inc., Ridge Avenue, Hanover, Pa., plans installation of electric power equipment in proposed new mill at Victoria, comprising several units. Entire project reported to cost over $50,000.

Wash., Hoquiam—Grays Harbor Pulp & Paper Co., plans installation of electric power equipment in new addition to plant, to be used for pulp division. Cost about $55,000. W. S. Lucey is vice-president and general manager.

Wis., Beloit—Electric Equipment Mfg. Co., 1326 Clary Street, plans one-story power house in connection with new factory unit, 150x200 ft. Proposed to begin work early in spring. Cost over $90,000. W. R. Cones is general manager.